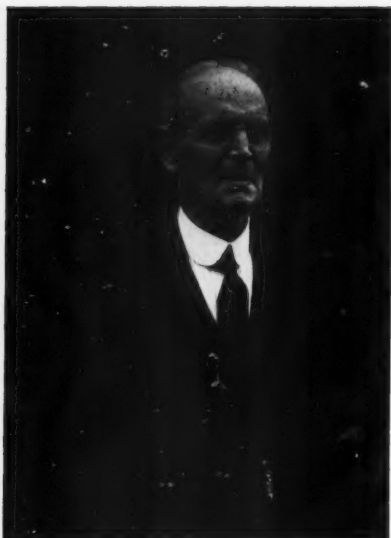


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Dr. Aitken, at the American Astronomical Society at Wellesley College in September, 1940.

## ROBERT GRANT AITKEN

**D**R. ROBERT G. AITKEN, director emeritus of Lick Observatory, belonged to an age of astronomy that, alas, seems to have passed largely out of existence. Today the photographic plate and the photocell have to a great extent replaced the human eye as a receiver of starlight. But Dr. Aitken, who died October 29, 1951, at the age of 86, observed when the human eye, next to the telescope itself, was a most important instrument in astronomy. And no one had keener eyes than Dr. Aitken.

I came to Lick Observatory in 1926, at the invitation of acting director Aitken. My observing duties included much spectrographic work at the 36-inch telescope. Dr. Aitken, by virtue of his age, usually took the first half of the night and I usually followed him, taking off the measuring micrometer and replacing it with the heavy spectrograph. Thus my tours of observing overlapped Dr. Aitken's.

On many occasions, he would ask me to wait while he took advantage of unusually fine seeing to measure the angle and separation of a particularly difficult double star, the field of astronomy to which he devoted most of his life. Occasionally he would invite me to sit beside him and look at some "beautiful" stellar pair or some special object that caught his imagination. When he actually pointed out to me the tiny companion star, almost lost in the blaze of a brilliant primary, I never ceased to marvel at the keenness of the eye that detected the faint companion originally. For, almost invariably, in the big catalogue on which he worked, these stars were distinguished by the prefix "A," the initial of the discoverer. They were

# Sky and TELESCOPE

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his old friends and he loved them. He seemed to be "visiting" them rather than merely observing stars. He had a detailed schedule set up, according to the type of star. Some he would return to as often as once a year; others he would check only every five or 10 years.

The double stars that occupied Dr. Aitken's attention were physical systems: stellar relatives bound together by the power of gravitation. The two stars were in orbital motion about one another and Dr. Aitken made his records to determine that motion in order to study further the nature of the gravitational tie.

Dr. Aitken's measures of stars extended over so many years that some of the stars completed not one, but several revolutions about each other during the period of his observing career. He always regarded that day as particularly

significant when he had tracked a star completely around its orbit, for then he could go on to make the additional studies that told so much about the nature of the stars, how much they "weigh," for example. Once he pointed out to me an exceptionally difficult star which he had followed in its complete orbit and which no astronomer in the world, other than himself, had been able to measure.

Aitken's love of astronomy developed early in his life, and he studied that subject at Williams College, from which he was graduated in 1887. In 1895, he came to Lick Observatory as a voluntary summer assistant and remained as an assistant astronomer. In 1923, when W. W. Campbell, then director of Lick Observatory, went to Berkeley to accept the presidency of the University of Cali-

(Continued on page 42)

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WHOLE NUMBER 122

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DECEMBER, 1951

**COVER:** The administration building of the U. S. Naval Observatory. The Nautical Almanac Office, with a professional staff of 18 members, occupies about half the first floor and a part of the second. In addition, a substantial amount of storage space in other parts of the building is required for its records, among which are many of the original computations for the planetary theories and tables that were constructed by Newcomb and Hill. Official U. S. Navy photograph. (See page 27.)

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**BACK COVER:** The globular or spheroidal galaxy NGC 4486, Messier 87, located in the heart of the Coma-Virgo region at  $12^{\text{h}} 28^{\text{m}}.3$ ,  $+12^{\circ} 40'$ . This striking 200-inch photograph resolves the outer galaxy into stars. Of the 10th apparent magnitude, M87 is some eight million light-years distant. Its apparent diameter is about 3.3 minutes of arc. Mount Wilson and Palomar Observatories photograph.

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# The Centennial of the American Nautical Almanac Office

By EDGAR W. WOOLARD, U. S. Naval Observatory

EVER SINCE the remote time in history when mariners first began to venture out of sight of land, the stars have been one of the principal aids upon which the navigator has relied to bring his ship from port to port. More than 22 centuries ago, the Greek poet Aratus wrote of the two bears that circle round the pole (*Phaenomena*, ll. 36-39):

*And Cynosura one men call by name,  
The other Helice; and on the deep,  
By Helice Achaicans steer their ships.  
In Cynosura, Phoenicians put their trust.*

The great era of maritime exploration that began in the 15th century, and the development of ocean commerce during the 16th and 17th centuries, brought an urgent need for improved methods of navigation, especially for a means of accurately determining longitude at sea. The Greenwich Observatory was founded in 1675 expressly to provide astronomical data that would meet this need. The earliest of the national ephemerides was the *Connaissance des Temps* of France, first issued for the year 1679. It was later developed, especially after 1760 under the direction of Lalande, into a volume designed to provide all the annual data needed either by astronomers or by navigators.

In 1766, the British *Nautical Almanac and Astronomical Ephemeris* was initiated with the volume for 1767. The British almanac came into general use on American ships, as well as by surveyors and astronomers in the United States. With the continued develop-

ment of our nation and its growth as a maritime power, increasing need was felt for a national ephemeris that would end the dependence of the United States on a foreign power for its means of navigation, and that would suit the special needs of American navigators and surveyors.

In the United States, the *American Nautical Almanac* is prepared by the Nautical Almanac Office at the United States Naval Observatory in Washington, D. C. This office has completed 100 years of service to navigators and astronomers. It was established in the Navy Department by an Act of Congress approved March 3, 1849; it was first set up in Cambridge, Mass., where library and printing facilities were available, and began work during the latter part of 1849. The first issue of the *Nautical Almanac* was for the year 1855, and was published in 1852. It formed a part of the first volume of a larger publication, the *American Ephemeris and Nautical Almanac* for 1855; and it was also printed separately. The period from the 100th anniversary in 1949 of the establishment of the Nautical Almanac Office to the forthcoming publication in 1952 of the 100th volume of the *American Ephemeris and Nautical Almanac* may properly be considered as the centennial of the office.

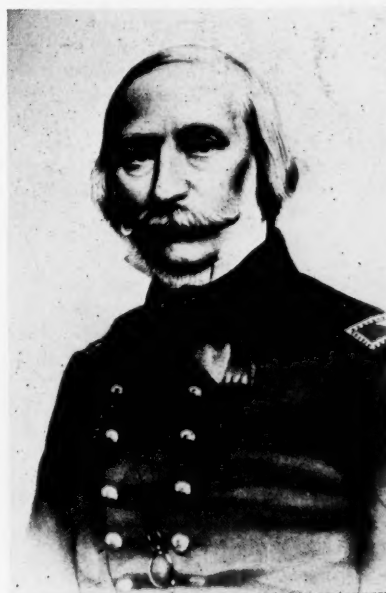
The Nautical Almanac Office was moved to Washington in 1866; but not until 1893 was it located at the Naval Observatory, pictured on the front cover. The Naval Observatory, established at Washington in 1844, is among the national government observatories that originated in the needs of navigation. This primary mission is reflected in its seal, emblematic of the union of sea and sky in the navigator's art. The seal portrays Urania with the globe in her outstretched hands, pointing out the way to unite the sky and the ocean; the seven stars, symbolizing the starry heavens, represent the seven planets of the ancients, and the wreath of wheaten blades and ears symbolizes Virgo and the navigational star Spica. The motto is taken from the astronomical poem written by Manilius in the early 1st century A. D. (*Astronomica*, Lib. IV, ll. 279-280):

*Adde gubernandi studium. Pervenit  
in astra  
Et pontum caelo coniunxit.*

*Then, too, the pilot's care: the stars  
are scaled,  
And sky with ocean joined.*

Since the initial volumes, for the year 1855, both the *American Ephemeris*

and the *American Nautical Almanac* have appeared annually without interruption; and beginning with 1941, another volume, the *American Air Almanac*, has been issued (in three parts annually) for air navigation. For the years 1855-1915 inclusive, the *American*



Charles Henry Davis, first superintendent of the U. S. Nautical Almanac, July 11, 1849, to November 23, 1856, and again from August 10, 1859, to September 18, 1861. He was also twice superintendent of the U. S. Naval Observatory, from April 28, 1865, to May 15, 1867, and February 23, 1874, to February 18, 1877. He translated Gauss' "*Theoria Motus Corporum Coelestium*" into English.

*Ephemeris* continued to be divided first into two distinct parts, then after 1881 into three. The first was an ephemeris for the use of navigators which, with a few pages from the other parts, was reprinted separately as the nautical almanac; but since 1916 this has been a separately prepared volume.

The early volumes of the almanac bear little resemblance to the most recent issue. Fundamentally, the same data have continued to be given — predictions of the positions of the sun, moon, bright planets, and navigational stars.

When the almanac was first issued, no attempt was made to provide the navigator with astronomical data especially adapted to his needs; the almanac contained the same ephemerides as were prepared for astronomical pur-



The seal of the U. S. Naval Observatory.

poses, in the same form and to the same degree of accuracy. The principal revisions by which it was brought to its present form were made in the volumes for 1916 and 1950. Until the revision in 1916 (at the time that extensive changes were also made in the *American Ephemeris*), the principal change in content had been the omission of the outmoded lunar distances, beginning with 1912. Few present-day navigators could now use the volumes in the form in which they appeared for 60 years!

The *American Nautical Almanac* for 1916 was designed especially for navigators. The precision required for astronomical purposes was replaced by only the degree of accuracy needed for navigation. The form and arrangement were based on a series of supplements and appendices to the almanac that had been issued during 1909-1915 in preparation for the revision. In particular, the form adopted in 1916 for the ephemeris of the sun, and the selection of 55 principal navigational stars (which with two other stars added in 1950 are still used), first appeared in the 1913 supplement.\*

Until the complete revision that again was made in the volume for 1950, the most notable change after 1916 was the addition of the Greenwich hour angle to the ephemeris of the moon in 1932, and to the ephemerides of the sun, planets, and stars in 1934. The Greenwich hour angle first appeared in a series of supplements issued during 1929-1931 for the special purpose of air navigation.

In the almanac for 1950, right ascensions were omitted, the arrangement was changed to a form similar to the *American Air Almanac*, and no material that is not directly required in navigation was included. Both the *Nautical Almanac* and the *Air Almanac* are now specifically adapted to the determination of geographical location by means of the

line of position; and each almanac is designed to aid the navigator in obtaining his position as accurately as necessary, with the least time and effort, under the actual conditions under which he must work.

The data on eclipses and planetary configurations formerly included in the *Nautical Almanac*, together with other material of wide general interest, are now available in a separate pamphlet entitled, "Astronomical Phenomena," which may be purchased from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

The *American Ephemeris and Nautical Almanac*, though no longer directly used for navigation, remains the basis for the preparation of the navigational almanacs, and retains the traditional title; and it continues to serve its other original purposes. It is the principal source of the astronomical data required for surveying, accurate time determination, and other practical purposes; it contains the fundamental ephemerides that are essential to astronomers for current use in planning, making, and reducing astronomical observations, and for permanent future reference in conducting astronomical investigations; and it provides a permanent annual record of astronomical phenomena for general reference.

The revisions that have been made in the *American Ephemeris* from time to time during the past 100 years to adapt it to changes in the needs of astronomers have not affected the general form and character as much as in the case of the *Nautical Almanac*; and the most recent volume differs less from the first volume than may superficially appear. A few omissions of material that was no longer useful have occurred—notably the tables of moon-culminating stars for determining longitude that were included until 1882, and the lunar distances for navigation. A number of important additions have been made—particularly ephemerides for physical observations of the sun, moon, and planets, ephemerides of the satellites,

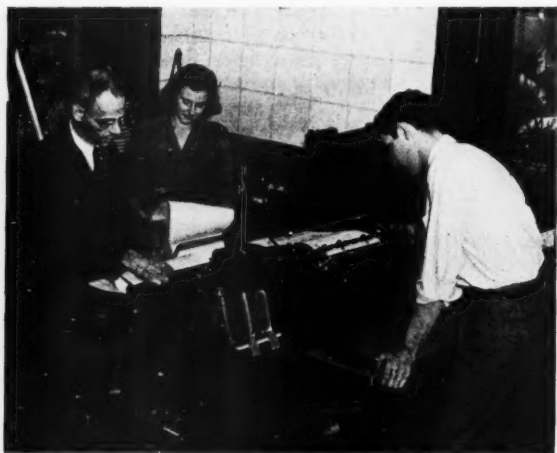
and the times of rising and setting of the sun and moon.

The principal revisions were in the volumes for 1882, 1912, 1913, and 1916. Until 1882, the original division into two parts was retained—the nautical part, containing ephemerides for the meridian of Greenwich; and an astronomical part, with the title "Astronomical Ephemeris for the Meridian of Washington," containing ephemerides of the sun, moon, planets, and principal stars, for meridian transit at Washington, together with eclipses, occultations, and miscellaneous other phenomena. From time to time in later years, subdivisions and rearrangements were made, until in 1937 the number of parts into which the volume was formally divided had increased to seven. The Washington Ephemeris had been reduced to only ephemerides of the sun, moon, and planets for meridian transit at Washington; and because of its limited usefulness except to observers on the Washington meridian, the publication of this part was discontinued after 1950.

The preparation annually of the *American Ephemeris*, the *American Nautical Almanac*, and the *American Air Almanac*, is the organic function of the Nautical Almanac Office, and constitutes the principal part of its work; but special computations are also undertaken, either for its own purposes or for other official agencies. The *American Ephemeris* and the national ephemerides issued by several other countries all have in large part the same content; and beginning with the volumes for 1916, the computations have been shared among the almanac offices of France, Germany, Great Britain, and the United States, in accordance with international agreements authorized by law. The American office also takes part in the preparation of the annual volume, *Apparent Places of Fundamental Stars*, which was established under the auspices of the International Astronomical Union, beginning with 1941.

The remaining efforts of the Nautical Almanac Office are devoted principally to investigations of the motions of the celestial bodies for the purpose of improving the theories and tables from which the ephemerides are computed. This has been an essential part of the work ever since this office was established in 1849. At that time, astronomers had been computing ephemerides more or less regularly, by a succession of different methods, for more than 2,000 years, and the law of gravitation had been known for nearly 200 years; but tables based on gravitational theories had been generally available for the bodies of the solar system for only about 50 years, and they still were so imperfect that it was commonly necessary to apply empirical corrections to

\*For some of the details of the successive changes, see W. J. Eckert, *Air Almanac, Sky and Telescope*, November, 1944; and Commander Edwin A. Beito, U.S.N.R., *The New Type 1950 Nautical Almanac*, U. S. Naval Inst. Proc., 75, 1394-1401, 1949.



Here the astronomer verifies figures produced by tabulator for the almanac. This machine adds and subtracts large numbers at the rate of 9,000 an hour. U. S. Navy Department photograph.

them from year to year. For the calculation of most of the ephemerides in the *American Ephemeris*, new tables were constructed, especially for this purpose, before the first volume was prepared; and in large part, the later improved tables by which these early tables were replaced were also constructed in the Nautical Almanac Office.

By directing the attention of American astronomers to the need for improved theories of the lunar and planetary motions, the *American Ephemeris* became an important factor in the notable contributions to celestial mechanics that have been made in America during the past 100 years.

The planetary theories and tables now in use were constructed by Simon Newcomb and G. W. Hill, during the period from 1877 to 1897 when Newcomb was director of the Nautical Almanac. They were based on values of the fundamental astronomical constants determined by Newcomb from all available observational data, and on a discussion of the observations of the sun and planets that had been made at all the principal observatories of the world since 1750. Newcomb also constructed a catalogue of 1,596 fundamental stars. The results of this program are contained in the classic volume by Newcomb, "The Elements of the Four Inner Planets and the Fundamental Constants of Astronomy," published as a supplement to the *American Ephemeris* for 1897; and in the first eight volumes of the *Astronomical Papers prepared for the use of the American Ephemeris and Nautical Almanac*, a series which was established by Newcomb for the purpose expressed by the title.

With a few exceptions and later small revisions, the system of constants and planetary tables constructed under Newcomb's direction was internationally adopted, and still remains in use. Newcomb's star catalogue was also used during 1900-1927; and the catalogue used during 1928-1939 was one constructed in the Nautical Almanac Office, by W. S. Eichelberger.

In the time that has elapsed since the work of Newcomb and Hill, a revision of the tables has become necessary, to remove limitations and defects which they have, and to meet the steadily increasing demands for tables of a higher order of accuracy. With the support of the Office of Naval Research, an extensive project for this purpose is now in progress, in which the Nautical Almanac Office, the Watson Scientific Computing Laboratory, and the Yale University Observatory are co-operating; and the first results have already been published in recent volumes of the *Astronomical Papers*.\*

\*For an account of one part of this project, see G. M. Clemence and Dirk Brouwer, *The Motions of the Five Outer Planets*, *Sky and Telescope*, February, 1951.

Most of the computation is now done with standard commercial punched card machines, the remainder with electric desk calculators. Logarithms are rarely used. Printers' copy for the *Air Almanac* and the *Nautical Almanac* is prepared directly from the computation cards by means of a card-operated typewriter, and is photographically reproduced. A large amount of proofreading is also done by punched card methods that were developed in the Nautical Almanac Office.\*

During its earliest years, the Nautical Almanac Office had no permanent staff beyond the superintendent and a few clerks and proofreaders. The superintendent contracted with various astronomers throughout the country for the computations; some of the most eminent American astronomers of the time took part in this work, and without their co-operation it is doubtful whether the project could have been successfully accomplished. The nucleus for a permanent staff was gradually formed; but as

\*See W. J. Eckert and Ralph F. Haupt, *The Printing of Mathematical Tables*, *Math. Tables and Aids to Comp.*, 2, 197-202, 1947.

late as 1878 less than half the staff were residents of Washington. Only in 1950 was the use of pieceworkers outside the office entirely discontinued.

Both in theoretical research and in the preparation of the annual ephemerides and almanacs, the Nautical Almanac Office is primarily a practical numerical computing laboratory. Astronomy has been noted throughout history for its numerical computations; and practical numerical methods have been highly developed by this long tradition of computing. In astronomical calculations, the great volume of computation that is required, the complexity and length of the separate calculations, and the unusually rigorous demands for accuracy necessitate that the highest standards of perfection and efficiency be maintained. The 1,700 pages in the annual publications of the office are almost entirely covered with numbers; in the *Air Almanac* alone, more than a million and a half figures are published every year. Life and property may depend upon no erroneous figure appearing in print.

## NEAREST GALAXIES AND BRIGHTEST

In a survey of the inner metagalaxy, published in the *American Scientist*, Dr. Harlow Shapley, of Harvard Observatory, gives two lists, one of the present known members of our local family of galaxies, the other of the apparently brightest external galaxies:

### THE LOCAL FAMILY OF GALAXIES

Name	Distance*	Type	Galactic Latitude	Absolute Magnitude
Our Galaxy	—	Spiral	—	—18:
Messier 31	750	Spiral	—20°	—18.0
Messier 33	780	Spiral	—31	—16.1
Large Magellanic Cloud	80	Irregular	—33	—16.1
Small Magellanic Cloud	80	Irregular	—45	—14.4
NGC 205	750	Spheroidal	—21	—13.5
Messier 32	750	Spheroidal	—22	—13.3
NGC 6822	520	Irregular	—20	—12.4
NGC 185	650:	Spheroidal	—14	—12.2
IC 1613	730	Irregular	—60	—12.0
NGC 147	650:	Spheroidal	—14	—11.9
Fornax	460:	Spheroidal	—64	—11.9
Sculptor	230	Spheroidal	—83	—10.6
Anon 1	650:	Spheroidal	+50	—
Anon 2	650:	Spheroidal	+69	—

\*In thousands of light-years; the colon indicates uncertainty.

### THE TWENTY BRIGHTEST GALAXIES

Name	Mean Pg. Mag.	Type*	R.A. 1950.0 h m	Dec. °	Galactic Latitude	Messier Number
Large Cloud	1.2	Irreg.	5 26	—69	—33°	—
Small Cloud	2.8	Irreg.	0 50	—73	—45	—
NGC 224	4.5	Sb	0 40.0	+41 00	—20	M31
598	6.7	Sc	1 31.1	+30 24	—31	M33
253	7.6	Sc	0 45.1	—25 34	—88	—
55	7.8	Scp	0 12.5	—39 30	—77	—
5236	8.0	Sc	13 34.3	—29 37	+32	M83
3031	8.1	Sb	9 51.5	+69 18	+42	M81
4594	8.6	Sa	12 37.3	—11 21	+51	M104
5457	8.6	Sc	14 1.4	+54 35	+60	M101
4826	8.7	Sb	12 54.3	+21 47	+82	M64
Sculptor	8.9	Epec.	0 58.9	—33 50	—83	—
NGC 4736	9.0	Sb	12 48.6	+41 23	+76	M94
Fornax	9.1	Epec.	2 39.4	—34 34	—64	—
NGC 3034	9.2	Irreg.	9 51.9	+69 56	+42	M82
4945	9.2	Sbp	13 2.4	—49 01	+12	—
221	9.3	E2pec.	0 40.0	+40 36	—22	M32
2403	9.3	Sc	7 32.0	+65 43	+30	—
5194	9.3	Sc	13 27.8	+47 27	+68	M51
205	9.5	Epec.	0 37.6	+41 25	—21	—

\*S, spiral; E, spheroidal.

# NEWS NOTES

By DORRIT HOFFLEIT

## HUMAN METEORITE TARGETS

In records from 1500 B.C. to the present, Dr. Lincoln LaPaz, Institute of Meteoritics, University of New Mexico, finds 14 reported cases where a meteorite presumably struck a human being or a domestic animal. In *Popular Astronomy* for October, he notes that although none of the 14 cases has been absolutely proved (the missile unambiguously identified as a meteorite) a few do appear plausible. Dr. LaPaz has applied the theory of probability to compute how often we might reasonably expect a human being to be hit by a meteorite.

Taking into account the average effective area of a human vulnerable to attack, the average size of the population, and the number of meteorites that probably reach the surface of the whole earth (350,000 per century), there is a 50-50 chance that one meteorite might hit a human target once in the three centuries from 1700 to 2000. The chances are 316 in 1,000 that at least one meteorite might strike someone somewhere in the world in the 20th century; and 99 to 1 that, in at least one of the centuries between A.D. 2100 and 3300, a meteorite will hit someone.

Dr. LaPaz comments that these odds are by no means as negligible as has usually been assumed from random guesses. They add credence to the most recently reported case of a Japanese child, who in 1928 was injured by a small stone (0.19 gram) which may have been an achondrite.

## LUNAR PHOTOMETRY

The heights of craters or of high jagged peaks on the moon are usually determined from measurements of the lengths of shadows cast on the surrounding surfaces. This technique does not suffice, however, for the heights of gently sloping ridges in the relatively smooth maria. In the *Bulletin of the Astronomical Institute of the Netherlands*, J. van Diggelen has investigated the possibilities of determining such lunar topography from photometric measurements. The relative brightness of areas on the moon depends on the orientation of the various surfaces to the incident light from the sun, as well as upon the angle between a surface and the direction of the observer.

If the albedo is the same for all of the areas considered, then for a small region near the terminator only the direction of the incident light varies considerably, and the relative orientations of adjacent surfaces can be determined directly from their relative apparent brightnesses. Thus van Diggelen chose the region of Mare Imbrium for study on

photographs taken by Professor M. Minnaert with the 40-inch Yerkes refractor. Assuming that the region was entirely covered by volcanic ash, he found that the gradients of all of the ridges in that area do not generally exceed one in 40. While the mean heights appear to vary between 100 and 200 meters, hills of from 10 to 20 meters are clearly visible.

## HOTTEST FLAME ON EARTH

No laboratory source could be found hotter than the flame of the hydrogen-fluorine torch invented by H. F. Priest and A. V. Grosse in 1947. Measurement of the temperature of the flame was only achieved this year by astronomer Raymond H. Wilson, Jr., now of Louisville University, and his associates at Temple University. Dr. Grosse, director of Temple University's Research Institute, recently reported that 46-percent fluorine burning in hydrogen had a temperature of 4,300° absolute at one atmosphere pressure (uncertainty 150°) and 4,750° at five atmospheres. It is expected that at 100 atmospheres a temperature of 5,400° can be achieved, equivalent to solar surface temperatures.

Dr. Wilson used a standard spectroscopic line-reversal technique wherein some substance such as sodium or lithium is introduced into the flame and viewed with a pyrometer projected before some hotter source. In accordance with the elementary laws of spectros-

copy, the flame will produce bright spectral lines, but these turn to dark absorption lines when viewed in front of the hotter source. As sodium is conspicuous in the solar spectrum, it could not be used, but lithium proved ideal, having only one-per-cent absorption at wave length 6708 angstroms (see *Sky and Telescope*, March, 1951, page 114).

## LEGAL PROBLEMS IN SPACE

In international law it is well established that national states have sovereignty over the atmosphere above their territories, but the law so far has not defined how far the atmosphere shall be considered to extend. This was pointed out by Oscar Schachter, of the United Nations legal department, at the symposium on space travel held on Columbus Day at the Hayden Planetarium in New York.

Now that humans have become space conscious in a much wider sense, just how far shall state sovereignty extend? Mr. Schachter suggests that to avoid interference with freedom of space travel the outer boundary of a state's territory be limited to the region known as the air space. He proposes that outer space be governed by rules similar to the international laws of the high seas; each national state would exercise jurisdiction only over its own space craft, persons, and goods. Because of possible grave consequences from military operations by space craft, there is a possibility that war might be outlawed in international space.

As for claims for celestial bodies, Mr. Schachter stated, "No doubt the great majority of people will find it difficult to accept the idea that the heavens themselves are to be parceled out among individual governments. In their view these bodies, like the outer space, should also remain free for use by all."

## AIR ALMANAC UNIFICATION

With the volumes for 1953, the *Air Almanac* and the *American Air Almanac* will become a single publication, under the title of the *Air Almanac*. It will be produced jointly by H. M. Nautical Almanac Office of the Royal Greenwich Observatory, Herstmonceux, and the Nautical Almanac Office of the U. S. Naval Observatory in Washington, to meet the general requirements for air navigation in the United Kingdom, the United States, and Canada. The *Air Almanac* will be printed and published separately in England and the United States but will otherwise be identical.

A number of changes have been necessary in both of the former publications. None of these has any effect on the principles of tabulation or on the use of the almanac in navigation.

## IN THE CURRENT JOURNALS

THE MUSLIM TRADITION IN ASTRONOMY, by H. J. J. Winter, *Endeavour*, July, 1951. "Muslim contributions to astronomy influenced the development of the science for roughly a thousand years. . . . They were responsible, through their great willingness to co-operate with scholars of other nations, for the wide diffusion of astronomical knowledge."

COSMIC ABUNDANCES OF THE ELEMENTS AND THE CHEMICAL COMPOSITION OF THE SOLAR SYSTEM, by Harold C. Urey, *American Scientist*, October, 1951. The moon "approximates the composition of the cosmic dust which formed the planets more nearly than does any other terrestrial planet. A discussion of the probable origin of meteorites leads to the suggestion that the chondrites may also approximate this composition."

DOUBLE STAR INTERFEROMETRY, by W. S. Finsen, *Popular Astronomy*, October, 1951. "With the simple slit interferometer one may increase the resolving power of a telescope by a factor of nearly 2.44. The gain is in many ways most immediate with small telescopes."

# The Date of the First Christmas

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IT MAY come as a distinct shock to some people to realize that the first Christmas did not occur 1,951 years ago. They will naturally say: "Is this not the year A.D. 1951 (anno Domini—in the year of our Lord)? Was He not, therefore, born 1,951 years ago?" No, we must admit this is not the year 1951. As a point of fact we don't know what year this is with any certainty. It may be 1958 or 1959.

It seems curious that so important a date in the history of the world should be shrouded in mystery. The truth is that not until the 6th century did anyone think highly enough of the event to begin dating history from it. In A.D. 533 Dionysius Exiguus (Denys the Little), abbot of Rome, examined all the records available at the time in order to determine the date of Jesus' birth. And though this determination was made in the 6th century, it did not come into general use until the 9th century. With all the care and precaution that was taken, some mistakes in establishing the date of the beginning of the Christian era were made, mistakes which cannot be rectified now because of the tremendous confusion which would result.

Dionysius found a statement made in the 2nd century by Clement of Alexandria (Titus Flavius Clemens), that Christ was born in the 28th year of the reign of Caesar Augustus. Augustus had assumed power in Rome after defeating the forces of Antony and Cleopatra in the naval battle at Actium in 31 B.C. and had reigned for almost four years under the name of Octavian. Dionysius, unaware of this fact, introduced an error in his reckoning by neglecting the reign of Octavian. In addition, the year zero which should have been inserted between the end of 1 B.C. and the beginning of A.D. 1, was omitted. This error was not the fault of Dionysius, for the symbol zero, of Hindu origin, was unknown to him. It was introduced to Europe several centuries later by the Arabs. The combination of these two errors sets the latest date of the birth back to the year 4 B.C.

For all other clues we must go to the Bible. In St. Matthew we read: "Now when Jesus was born in Bethlehem in Judaea, in the days of Herod the king, behold, there came wise men from the East to Jerusalem, saying: 'Where is he that is born King of the Jews? For we have seen his star in the East; and we are come to worship him.'"

The pertinent item in this passage is the statement "in the days of Herod the king," during which Jesus lived.

This date can be uncovered by consulting the works of the great Jewish historian, Flavius Josephus, who wrote the books *Wars of the Jews* and *Antiquities of the Jews* in the 1st century of the Christian era. In *Antiquities*, Josephus relates that Herod became very ill when he was 70 years old. A new high priest had to be appointed for a single day to officiate at the feast of the *Purim* which fell on the day of the full moon before the beginning of spring. Josephus goes on to say that on that night there was a slight partial eclipse of the moon. From the information that a partial eclipse took place just before spring and was visible from Jericho, it is possible for the astronomer to assign the exact date of this eclipse, which he finds took place on March 13, 4 B.C.

Shortly after the eclipse Herod died. Josephus goes on to say that after the traditional seven days of mourning the Passover was celebrated. As, in 4 B.C., the Passover fell on April 12th, if seven days are deducted we arrive at April 5th. This means that Herod must have died sometime between March 13th and April 5th. The latter date is the latest at which Jesus' birth could have taken place.

This takes care of the latest date. What of the earliest date? Here once more recourse must be made to Biblical authorities. In St. Luke we read: "...there went out a decree from Caesar Augustus, that all the world should be taxed.... And Joseph also went up from Galilee... unto the city of David, which is called Bethlehem, because he was of the house and lineage of David." The exact time of the taxation mentioned in this passage was unknown for a long time. However, in 1923, near Ankara, Turkey, there was found a Roman temple inscription which, when deciphered, relates that in the reign of Caesar Augustus there were three great tax collections. One was in 28 B.C., the second in 8 B.C., and the third in A.D. 14. It is certain that the taxation in 28 B.C. was much too early; it was too close to the accession of Augustus. The taxation that took place in A.D. 14 was much too late; it followed too long after the death of Herod. The only period fitting the puzzle is that of 8 B.C.

It should be remembered the tax laws were promulgated in Rome, and in those days of slow transportation and slow communication it took quite some time for tax collectors to work their way eastward, town by town, province by province, until they finally came to Bethlehem in Judaea. The combination

of the above two effects may have resulted in a delay of a year or two. This indicates that the most likely date for the birth of Jesus is 7 or 6 B.C.

While this narrows down the year of the Nativity, nothing has been said about the time of the year. Of one thing we are certain, the traditional date for Christmas, December 25th, is incorrect. Jesus was not born in the wintertime. In St. Luke there is found a clue as to the time of the year. For there we find: "And there were in the same country shepherds abiding in the field, keeping watch over their flock by night." The only time the shepherds watched their flocks was in the spring when the baby lambs were being born. At other times the sheep were left to graze or were put into corrals. Therefore, the time of the year must have been the spring. So the spring of the year 7 or 6 B.C. is the most likely time for the Nativity.

The early Christians could not celebrate the true date for they would have been subject to persecution by the Roman soldiers. To avoid this, the date for the celebration was moved all over the calendar, with March 20th, April 20th, May 20th, and September 29th being some of the dates.

December 25th has come down to us because that date was a traditional day of celebration among many peoples. That was the day on which the sun had gone as far south as it could, and from then on it would swing north, bringing with it the spring and summer. At this time the Romans celebrated the Saturnalia, festival of the husbandman, which had begun with good feeling and festivity, but gradually developed into a riotous celebration. To escape persecution, which incidentally continued to the middle of the 4th century, the Christians had the celebration of the Nativity come at the same time as the Saturnalia—blending of the two permitted the proper observance.

## HARVARD DIRECTOR TO RETIRE

Dr. Harlow Shapley will retire from the directorship of Harvard College Observatory next summer. This is in accordance with a Harvard University statute providing for the automatic retirement of administrative officials at the age of 66.

The Harvard astronomer expects thereafter, as Paine professor of practical astronomy, to undertake additional research on galaxies and the "hub of the universe" project of the observatory. He will give a new half-course, provisionally entitled "Cosmography," in the general education program of the university, "to emphasize the basic unity of substances and operations throughout the inanimate and organic world."

# Radar Observations of Meteors

By OTTO STRUVE, *Berkeley Astronomical Department, University of California*

**A** ROUGH, unpaved road leads from the main campus of Stanford University, at Palo Alto, Calif., to an open field with a small shelter in the middle. There a network of wires and cables spreads out to several metal rods and ordinary wire antennas. Inside the shelter is an assortment of electronic equipment. A motor is humming and two pens on a recorder trace out pulses of electrical energy on a long strip of paper. We watch the record and for about a minute the pens trace two straight lines. Then, all of a sudden, the pens begin to vibrate wildly and the tracing shows peculiar markings, like damped oscillations, with approximately constant frequency and decreasing amplitude. The radar telescope has just recorded an invisible, daytime meteor!

While the recorder traces out the oscillations of the pens, several electronic oscilloscopes show simultaneous disturbances of the brilliant green spots and lines that remain stationary when there is no meteor. One oscilloscope has a spot which rapidly describes a ragged-looking spiral while the meteor is in flight; the other, with a horizontal paper scale calibrated in kilometers, suddenly shows a vertical luminous dart at the position on the fluorescent face of the receiver that corresponds to the distance of the meteor from the observatory.

The meteor observatory at Stanford University is the research station of O. G. Villard, L. A. Manning, and A. M. Peterson. It is now used principally to study the properties of the upper atmosphere, partly in co-operation with N. Herlofson's work on the ionosphere. I visited it several months ago because the editor of *Sky and Telescope* had asked me to review the meteor work of D. W. R. McKinley at the National Research Council of Canada, in Ottawa, published in the *Astrophysical Journal* for March, 1951.

Fortunately, the months of May, June, and July are especially rich in daytime meteors belonging to several radiants which are below the horizon at night. These were, therefore, unknown to astronomers until they were discovered in 1947 by Lovell, Clegg, and Hughes, at the radio observatory near Manchester, England. This circum-

stance enabled me to "see" some 60 meteors on the Stanford radar tracings in the course of about 15 minutes, whereas ordinarily only a few would have been observed during the late afternoon—when the frequency of all meteors, visual, photographic, and radar, is near its lowest ebb.

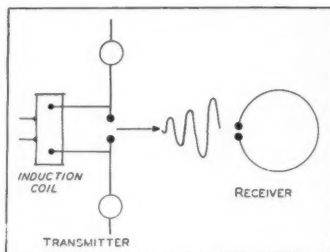


Fig. 1. The plan of Hertz' apparatus to produce and analyze electromagnetic radiation of radio wave lengths.

In 1888, a young German physicist, Heinrich Hertz, began experimenting with an electric spark between two metal rods separated by a small gap. The spark was produced by an induction coil, and set up an oscillating current in the two rods. At a distance of a few hundred feet, Hertz placed a loop of wire with its ends brought almost in contact (Fig. 1). Ordinarily nothing could be observed in the gap of this receiving loop, but as the lengths of the two rods in the transmitting spark were changed, a small spark could be seen in the gap of the receiver.

In this manner Hertz not only produced and explained electromagnetic waves, but he demonstrated their properties of reflection, interference, and refraction. Thus, with a large metal plate behind the transmitter he could reinforce the invisible waves and increase the intensity of the spark in the receiver; and with a large lens of pitch he focused the waves accurately upon the receiver and obtained an intense spot of electromagnetic radiation.

In modern radio technique, a vacuum tube is used to produce powerful electromagnetic oscillations in a suitable antenna, and these are radiated into space, to be picked up by a tuned receiving set.

It has been known for a long time that radio waves travel over great dis-

tances, because they may be reflected by a layer of electrically charged atoms and molecules in the upper atmosphere. But the reflectivity is not the same for all wave lengths, nor is it the same throughout the day and the night. The shorter waves, used in ordinary radar and in television, are transmitted by the upper atmosphere and can usually be recorded only by those receivers that are within sight of the transmitting antenna. These wave lengths range from several meters to several centimeters (one meter corresponds to a frequency of 300 megacycles per second), and are emitted from a dipole radiator having a length equal to the desired wave length, or to one half of it. In principle, such a dipole corresponds to the overall length of Hertz' two metal rods, with the spark gap between.

In the short-wave type of radar, where it is necessary to limit the direction of the outgoing beam, the dipole is often mounted in front of a parabolic reflector made of sheet metal. But in order for this to be efficient, the aperture of the reflector must be many times greater than the wave length of the dipole. Hence, for longer waves, of the order of one meter or greater, such reflectors are generally impractical. Instead, some degree of directivity may be obtained with the help of suitably placed wire antennas, whose radiation is reinforced in certain directions by screens of wire netting which act as reflectors and directors.

The use of radio waves in the exploration of the ionosphere is associated especially with the name of Sir Edward Appleton, of Edinburgh, and has led to the discovery that the reflecting layer is not uniform, but consists of several distinct strata. One of these, called the E layer, is at a height of around 100 kilometers. This is also where meteors are usually observed visually or on direct photographs. The reflecting properties of the E layer are controlled by the ultraviolet light of the sun, which knocks off occasional electrons from their parent molecules, leaving the latter in the ionized condition; thus they are electrically charged and exert an influence upon the electromagnetic waves with which they collide.

But in addition to this regular ionization, which changes in a predictable manner from day to night, there are occasional irregular strata of reflecting ionized gas at about 100 kilometers elevation that have no detectable connection with any solar phenomena. In 1932, Skellett, Schafer, and Goodall, and, independently, Pickard, found that

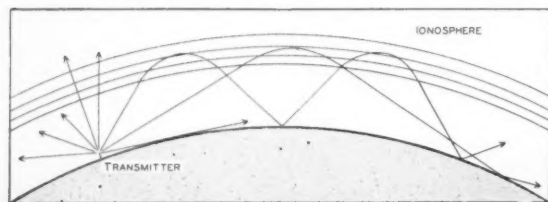


Fig. 2. The ionosphere permits some wave lengths to pass directly through it, whereas others are refracted in such a manner that they return to the earth, where a further reflection may take place.

these sporadic increases of E-layer ionization occur simultaneously with the passage of visually observed meteors, and this early conclusion was firmly established in 1947 by the work of Appleton and Naismith. Apparently, a large meteor leaves a residue of ionized material which merges with the normal E layer and modifies its properties.

With sufficiently powerful apparatus, however, emitting waves that are normally transmitted by the E layer and its sporadic disturbances, it is occasionally possible to observe echoes of very short duration arising at heights of about 100 kilometers. These transient echoes were noted by Schafer and Goodall during the Leonid meteor shower, and were recognized by Appleton, Naismith, and Ingram as a normal occurrence probably produced by sporadic meteors.

As a rule, these meteoric echoes of radar waves are observed on the face of a cathode-ray oscilloscope—an instrument which records in the form of a luminous curve the detailed variation of the rapidly changing electric current in the receiver antenna. When the antenna is not activated by the echo of a meteor, the oscilloscope records a spot which scans rapidly along a horizontal line. Usually, the transmitter is not completely eliminated by shielding, but is permitted to activate the receiver antenna for a *pulse* of a small fraction of one second. During this interval, the spot on the screen of the oscilloscope moves vertically upward as at *T* in Fig. 3. If the reflecting source is 90 miles away, then an echo is received after  $(90 + 90)/186,000$  second or about  $1/1,000$  second, because the wave first goes out 90 miles and then returns over nearly the same path. If the scanning of the indicator spot is very rapid from left to right, the disturbance will appear shifted to the right by an amount corresponding to this delay in the return of the echo, as related to the speed of the scanning spot.

If the distance of the target is constant, the echo *R* in Fig. 3 remains stationary; but if the target is approaching, the spot shifts to the left as successive pulses are recorded. On the face of the oscilloscope the successive pulses overlap and the persistence of vision shows the effect illustrated by *R*<sub>2</sub>

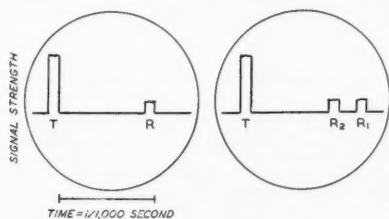
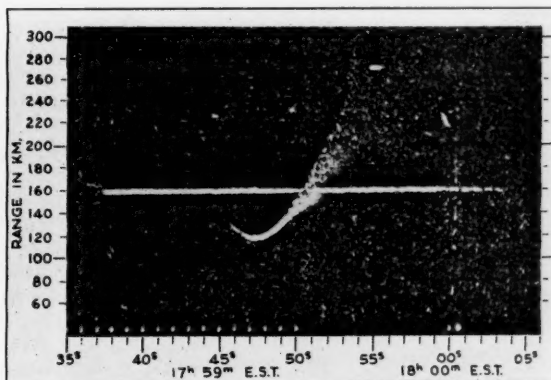


Fig. 3. If the meteor is approaching the receiver, successive pulses will be shifted to the left, from *R*<sub>1</sub> to *R*<sub>2</sub> in the right-hand part of this diagram.

and *R*<sub>1</sub>. The conventional technique is to photograph the oscilloscope screen on motion picture film. This produces hyperbolic echoes on the film, which record the change in the distance of the meteor (Fig. 4).

From the hyperbolic curves it is possible to compute the velocity of the meteor because its distance, *R*, at any time, *t*, exceeds that at the moment of nearest approach, *R*<sub>0</sub>, by an amount that de-

Fig. 4. The range-time record of radar meteors at Ottawa on August 4, 1948, by McKinley and Millman. The hyperbolic echo is remarkable for its length of path visible by radar. The horizontal echo from a long-enduring train first appeared at a height of 101 kilometers, ground range 120 kilometers. Two other short echoes are visible. Reproduced from the "Canadian Journal of Research," 27-A, May, 1949.



pends upon the elapsed time  $(t - t_0)$  and the velocity, *v*. In fact, the expression for the distance:

$$R^2 = R_0^2 + v^2 (t - t_0)^2,$$

defines a hyperbola. Successive values of *R* and *t* can be read from the film. Hence, the only unknown, *v*, can be easily computed.

These hyperbolic echoes are not always as beautifully defined as in Fig. 4. Sometimes they are complicated by extraneous disturbances; the resulting hyperbolas cannot be defined without ambiguity. Furthermore, in many cases the echoes are not hyperbolic in outline, but appear as nearly straight, horizontal lines on the films (Fig. 4).

P. M. Millman, of the Ottawa Observatory, who has collaborated with McKinley in radar work on meteors (see *Sky and Telescope*, March, 1949, page 114), has shown convincingly that the hyperbolic echoes correspond to the meteor in its motion. The meteoric particle itself is usually too small to produce an echo, but its ultraviolet light creates something like a huge ball of lightning around the particle, consisting of ionized atoms and molecules of air and moving with the meteor. This does not last after the passage of the meteor because rapid recombination of the ionized atoms of oxygen and nitrogen with free electrons renders them electrically neutral.

The long-enduring horizontal echoes are produced by the trains of meteors which contain ionized atoms of iron, calcium, magnesium, silicon, and the like. Millman calls this the basic ionization of a meteor, and he points out the difficulty of explaining average durations of 15 seconds, in the case of zero-

magnitude Perseid meteors. Perhaps, he suggests, the cone of a train, which may be some 30 kilometers in length and a few meters in cross-section, is filled with heat energy that is 10,000 times greater than the energy required to produce the observed numbers of free electrons in the train. Undoubtedly, the molecular velocities within the train are extremely violent, and because of the low density they may persist long

enough to replenish the free electrons, thereby counteracting the effect of recombinations.

The radar method is extremely sensitive. It records many more meteors than can be observed visually, and the Stanford observers believe that the frequency of small meteors may be even greater than was predicted many years ago, by F. G. Watson from visual data. But radar efficiently records only those meteors whose paths are at nearly right angles to the incident beam of radar waves, because the reflection is specular. We must think of the ionized train as a highly polished cylinder or narrow cone. Radiation falling upon it at an angle differing substantially from 90 degrees is reflected in other directions; only close to 90 degrees will the beam be reflected back to the receiver.

This is quite at variance with the visual method of observing, which is most efficient in the vicinity of the meteor radiant. Thus, in the case of the great shower of the Giacobini-Zinner comet in 1946, Lovell, Banwell, and Clegg found that when their directional radar was pointed toward the radiant the number of echoes dropped to about four per cent of the number observed at right angles to the radiant.

Incidentally, the same meteor shower enabled Hey, Parsons, and Stewart for the first time to determine the velocities of meteors from the hyperbolic echoes. They found 22.9 kilometers a second, which agrees well with the visually determined value, 23.7 kilometers a second.

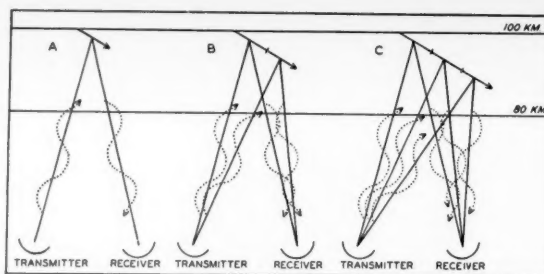
In recent years the hyperbolic echo method has been largely supplanted by a new technique based upon the phe-

nomenon of "whistling meteors." About 10 years ago, Chamanlal and Ventkataraman noticed that when the receiving set was connected to a loudspeaker the passage of a meteor could often be distinguished from other types of static by a peculiar whistling sound of gradually lowered pitch. Villard and others encountered this same phenomenon during the war in ordinary radar installations. On a recorder tracing, the whistle appears as a damped oscillation with increasing (or occasionally decreasing) amplitude and decreasing (or occasionally increasing) frequency. This phenomenon is caused by the fact that as the meteor moves forward its train remains behind, and thus grows in length. Consider Fig. 5, which is schematic. In A, at the beginning of the train, the small element of reflecting gaseous cone at the top reflects a wave which is registered at the receiver. In B, a small fraction of a second later, the wave reflected from the lower half arrives at the receiver out of phase with the wave reflected from the element formed in the beginning. The waves cancel and the receiver records nothing. Another fraction of a second later the most recently formed element of the train again is registered, even though the former two waves still cancel one another.

As the meteor comes closer and closer, and approaches its smallest distance from the observatory, the elements become longer and longer, and the intervals of time required to obtain complete cancellation are also lengthened. Finally, if the meteor is not burned up after it has passed the point at which the waves strike it at a right angle, the trend is reversed — the frequency of the oscillation on the recorder increases, and the amplitude diminishes.

In different forms this method of the whistling meteors has been successfully used at most meteor observatories. It is the basis of McKinley's new work in meteor velocities. Fig. 6 shows one of McKinley's records. He has estimated that the new technique can be used for many more meteors than the hyperbolic echo method, by a factor of about 1,000! A modification of the same method has enabled the Stanford group to measure not only the velocity of the meteor itself, which enters in relation to the speed with which the complete path is traversed, but the velocity of the air in

Fig. 5. The manner in which a meteor produces Doppler "whistles." The diagram is schematic, as each component of the reflecting cone is short compared to the total path length.



which the train of ionized gas is suspended.

In actual practice the interpretation of observed meteor whistles, now no longer heard over a loudspeaker but recorded as oscillations on a strip of paper, is more complicated. There is usually some interference from the direct wave of the transmitter, but these complications are all straightforward and can be allowed for.

When this was done in the case of nearly 11,000 meteors recorded during 847 hours of observing from December, 1948, to March, 1950, McKinley had at his disposal a large amount of homogeneous material on the velocities of the meteors with respect to the earth. Perhaps his most interesting finding is the total absence of any velocity in excess of 83 kilometers per second, and the existence of only nine in the range 80-84 kilometers per second. However, these, upon re-examination, proved to be quite uncertain. The revised velocities placed 32 meteors in the range 75-79 kilometers per second.

The real velocity of a meteor with respect to the sun must be less than 42 kilometers a second in order that the object be a permanent member of the solar system. If the velocity is greater, the object moves in a hyperbolic orbit and will soon escape from the solar system. The orbital velocity of the earth is about 30 kilometers a second. When a meteor overtakes us at its limiting velocity of 42 kilometers per second, the net observed velocity will be 12 kilometers per second; but if it hits us *face-on*, we should observe it with a velocity of 72 kilometers per second. This limiting velocity is still slightly increased by the attraction of the earth, so that any meteor having an observed radar velocity of more than 74 kilometers per second is likely to escape into interstellar space (unless it is burned up in our atmosphere).

The fact that only 32 out of nearly 11,000 meteors have such escape velocities shows that interstellar meteors, if they exist at all, must be quite rare. Moreover, the fact that a meteor now possesses an escape velocity and will ultimately become interstellar does not mean that it has come to us from interstellar space. It is much more probable that, having originated within the solar system, the meteor has been perturbed by the attraction of the planets and has thus assumed a slightly hyperbolic velocity which it did not previously possess. This would explain why there are no meteors with velocities that greatly exceed the limiting value.

Not all authorities agree that most meteors are members of the solar system. In particular, E. J. Opik, less than a year ago, put forward a strong case in favor of large numbers of interstellar meteors. His arguments are rather involved and fall into two categories. First, there remains the evidence of the older methods: Schiaparelli and H. A. Newton independently found a *mean* velocity near the escape value, suggesting that many meteors must be hyperbolic. The other result is based upon Opik's own estimates made with a rocking mirror. More serious is Opik's criticism of the statistical limitations of the radar method. But he was acquainted only with the earlier work by Lovell and his associates. There has been no time for him to take a stand in regard to McKinley's discussion.

The only other leading meteor astronomer who still believes that many meteors are hyperbolic is C. Hoffmeister, who is presumably influenced by his own earlier results on the Scorpius shower.

On this continent, F. L. Whipple and Millman agree with McKinley, and a similar conclusion has been reached in England by J. J. Porter, from the British meteor observations.

Among the many other results of the radar observations, we may mention that as a rule, with high sensitivity, the usual showers, such as the Perseids, stand out less conspicuously than they do when visual observations are analyzed. This is a clear indication that shower meteors and sporadic meteors are not physically identical. The showers abound in large meteors, while the sporadic meteors are especially fre-

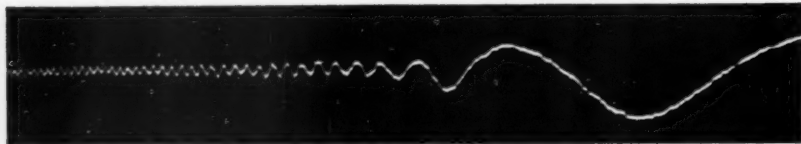


Fig. 6. A Doppler "whistle" recorded by D. W. R. McKinley, from an approaching meteor. The vertical fluctuations are in the voltage output of a DC-coupled receiver. The total time horizontally is 0.2 second. National Research Council of Canada photograph.

quent among the faintest echoes. Such a difference may be important. According to F. C. Leonard, all fallen meteorites are sporadic; there are no authenticated specimens from any recognized shower. The irregular shape of these chunks of iron or stone strongly speaks in favor of their collisional origin.

On the other hand, those meteors that are associated with comets must have originated at the time when Whipple's "snowballs of frozen ices with their imbedded grains of heavier particles" were formed. Unless collisions were frequent since the meteors were thawed out of the original comet, we would expect them to be either spherical in shape or symmetrical within the crystalline structure of their substance. There is no direct way, at present, to test this point. But it is certainly very suggestive that two kinds of meteors are recognizable in the radar observations, and that the two are associated with the cometary and the sporadic objects, respectively.

#### DECEMBER MEETINGS IN CLEVELAND AND PHILADELPHIA

The American Astronomical Society will hold its 86th meeting at Tomlinson Hall, Case Institute of Technology, and the Warner and Swasey Observatory, East Cleveland, on December 26-29. The first session for papers will be Thursday, December 27th, at 9:30 a.m. The Russell lecture will be given Thursday evening, with Dr. Jan H. Oort, of Leiden, Holland, speaking on "Problems of Galactic Structure."

The symposium Friday afternoon will be on "The H-R Diagram." Participants will be Drs. Dirk Brouwer, W. J. Luyten, W. W. Morgan, Martin Schwarzschild, and Bengt Stroemgren. The society dinner will be held Friday evening. On Saturday afternoon, a teachers' committee meeting and a visit to the observatory conclude the program.

Following the AAS meeting, Section D of the American Association for the Advancement of Science will convene in Philadelphia at the Franklin Institute, with the Rittenhouse Astronomical Society and the Amateur Astronomers of the Franklin Institute as hosts. The address of the retiring vice-president of Section D, Dr. C. D. Shane, of Lick Observatory, on "A Cosmic Census," will be presented Sunday evening, December 30th. On Monday there will be a symposium on "Astronomical Photoelectric Photometry: Recent Developments in Techniques and Instrumentation." Drs. Albert P. Linnell, John S. Hall, William Blitzstein, Bengt Stroemgren, and Albert E. Whitford will participate.

# A Constellation Viewer for Groups

By FRANK A. MYERS, *Junior Astronomy Club*  
*Cleveland Museum of Natural History*

**A**MONG amateur astronomers often one gadget suggests another.

The inspiration for our constellation viewer came from reading about the viewer that Vincent Anyzeski made, which was pictured in the June, 1949, issue of this magazine. His viewer consists of two oatmeal cans mounted on a stick. The instructor looks through one can; the learner looks through the other can and sees whatever constellation the instructor is aiming at.

Lester Nells and I were looking for an easy way to teach constellations to teen-age youngsters. We are both active in scouting. Together we have helped over 500 budding junior astronomers make a simple 8-power telescope in the Cleveland Junior Astronomy Club (*Sky and Telescope*, September, 1949).

A flashlight beam makes an excellent star pointer for group instruction, but some learners find it difficult to remember the constellation after it has been pointed out. Anyzeski's viewer aims the learner's eyes to a particular portion of the sky, but with it only one learner can look at a time. If you are instructing a group, then the rest have to wait in line. When youngsters have to do that, they often lose interest. Thus, we thought of making a number of viewers so mounted that each could be set up and pointed to a different constellation. The need for an instructor at each station could be eliminated by locking each viewer in position.

We proposed to mount 10 viewers in a circle, with 20 learners observing

at one time. After learning the constellation shown in one viewer, each person would move on to the next one. A rotatable constellation chart, provision for adjustment in altitude and azimuth, rigidity of construction, and cost were the important factors to consider in designing our viewer. We used old auto oil cans, 2-by-4 lumber, electrical conduit and pipe.

With the help of three scouts, Mr. Nells and I made 30 viewers in June, 1951. A set of 10 was presented to the Cleveland Junior Astronomy Club, for use in the museum's summer nature camp. Two sets were given to the Greater Cleveland Council of the Boy Scouts. One set was installed at Camp Beaumont, the other at the Chagrin Falls camp. Another excellent use for viewers would be at public star parties.

At Camp Beaumont, the 10 viewers were mounted on the parade ground in a semicircle. To sustain group interest before it got dark, all viewers were pointed toward Venus, which the instructor first located with binoculars. After a little practice with the finders, most of the scouts could locate the planet a half hour or more before sunset. As each viewer was later aimed at a constellation, the circular star map was rotated to match the constellation position. With a powerful flashlight the instructor first pointed out each of the 10 constellations, telling the legend of each, the names of the principal stars, and interesting facts about them.

Then the group divided up to look through the viewers, 20 scouts at one

With a star chart in front of him and the constellation isolated by the viewer, the learner can look from one to the other until he has the pattern firmly fixed in his mind.

One thumbscrew allows the viewer to be raised or lowered and another varies the vertical angle of viewing.



time. Each scout wrapped a piece of red cellophane around the end of his flashlight with a rubber band. Thus he could illuminate the constellation chart with light that would not spoil his night vision. He could look back and forth, from the stars to the chart, until the constellation star pattern was fixed in his mind. Then he moved to the next viewer to identify another constellation. About every 20 or 30 minutes the instructor adjusted each viewer to keep it aimed correctly, and the star chart correctly rotated, as the heavens revolved.

The construction design is evident from the exploded view, and the numbered parts are:

1. *Viewing tubes.* Pick up empty cans at your local gas station, five-quart size, about 6½" in diameter. This is large enough for an adult to see through comfortably with both eyes (the Big Dipper just fits nicely). Cut out top and bottom with a rotary wheel can opener.

2. *Crossbar.* Wood 2" by 4" cut 18" long spaces the cans far enough apart so two adults can look through, standing side by side.

3. *Angle braces.* The oil cans have two holes drilled to fasten to the angle braces with short machine screws and nuts. Use two 2" machine screws to fasten each pair of angles to the crossbar. These angle braces are 2½" x 2½" x ⅝", standard hardware items.

4. *Mounting angles.* These are 2" long, cut from 2" x 2" x ⅛" stock, fastened to the crossbar with ¼" carriage bolts, 4" long. The vertical side of each angle is drilled for a ⅜" carriage bolt, 2" long, one hole filed square to fit the head of the bolt. When this bolt is tightened with the wing nut, the vertical sides of the mounting angles press against the flat ends of the cylindrical bearing (5). This locks the altitude setting of the viewer.

5. *Center bearing.* This is 1¾" in diameter, 1½" long, with its center hole ⅜" in diameter. We pressed together three different diameter pieces of bakelite tubing to make a solid core. This bearing could be made out of a 1⅝" diameter hardwood dowel, with an outer tight-fitting metal tube to prevent splitting when the dowel is tapped. The side of the cylinder is tapped with a ⅜" pipe tap, to take the metal pipe reducer (6).

6. *Pipe-reducer screw socket.* For storage, the quickest disassembly is to unscrew the upright pipe (7) from the center bearing. This would soon strip the threads, if wood or bakelite were used. So we used a ⅜" to ¼" pipe-reducer bushing, its outer threads coated with shellac and screwed into the center bearing for a permanent fit.

7. *Upright sliding inner pipe.* This is ¼" black steel water or gas pipe 24" long, threaded at one end to fit the pipe reducer (6). This slides up and down inside the stationary pipe (8) to adjust for the proper viewing height.

8. *Upright outer pipe.* This is ½" heavy-wall electrical conduit pipe 60" long; it provides an easy sliding fit for the sliding inner pipe (7). About 3" from the top, open end, a thick machine nut is brazed on, and the pipe is tapped through the nut for a 5/16" short

thumbscrew, to lock the inner pipe in position. The bottom end of the upright can be cut at an angle to drive it a foot into the ground. Note that we plugged the bottom opening to prevent dirt collection.

9. *Pipe driver.* This is designed to be pounded with hammer or sledge; it prevents the upper end of the pipe from being deformed by the pounding. A loose-fitting large-headed bolt can also be used for this purpose.

10. *Circular star chart.* Our charts are photographic enlargements of charts from a good star-study book. They are mounted on 1/16" stiff aluminum sheet cut circular, 7" diameter, with a band saw. A tin can lid, painted aluminum, can also be used. The chart is fastened to the crossbar with a bracket and shouldered thumbscrew. Pliobond rubber cement was used to mount the charts; it sets very fast, so we had to thin it with acetone, apply cement to both surfaces with a 2" wide brush, and work fast. Clear lacquer waterproofed the outside surface, and this was later waxed to prevent the charts from sticking together when stored face to face in a special case we made to hold 20 charts in slots.

11. *Card holder.* Twenty identification cards, 3" by 5", were made of white plastic sheet with black waterproof lettering. These were mounted in metal frames nailed to masonite backing which can be fastened to the inner pipe with a ¼" pipe clamp.

All viewer parts were painted aluminum on the outside to aid seeing them at night. The insides of the viewer tubes were painted dead flat black to avoid light reflections while observing.

*Optical performance.* This one-power viewer has wide field. It has no chromatic and spherical aberrations, since it contains no lenses. No dewcap or tube-wall insulation is necessary, since it is impossible for dew to form in the optical path, except in a heavy rainstorm!

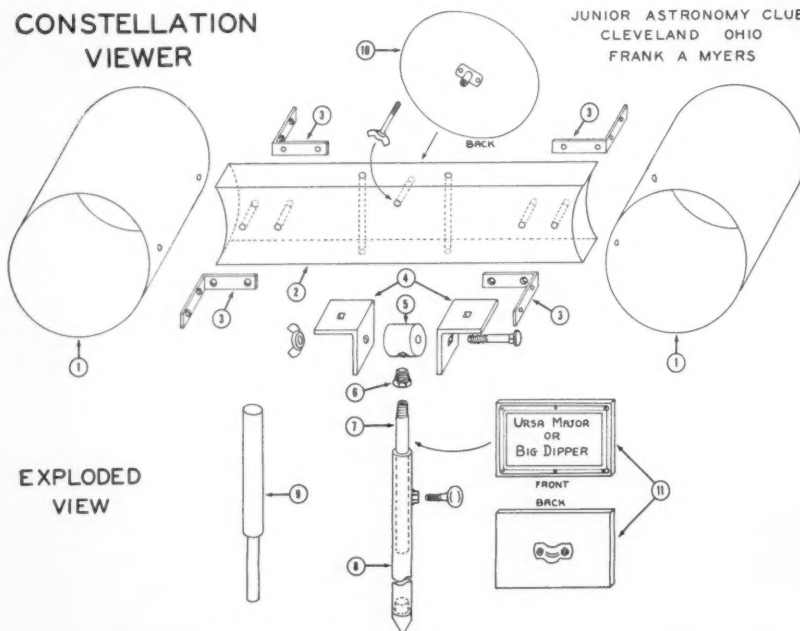
By the way, the automotive oil companies are great patrons of astronomy. One named its lubrication system after the star Marfak ( $\alpha$  Persei). Another chose Pegasus for its trade-mark. For our oil cans we patronized the oil company named after our nearest star.

## ATM'S WANTED

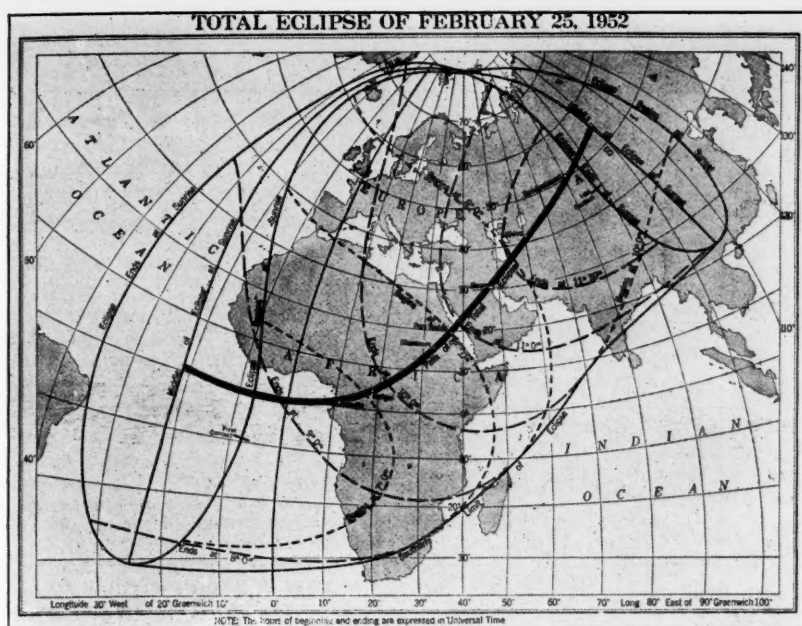
The Chrysler Corporation is calling for amateur telescope makers to help produce rangefinders at the company's Airtemp division in Dayton, Ohio, according to C. E. Buchholzer, Airtemp president. The need is for persons who have built and operated their own telescopes. Already advertisements for amateur astronomers have been carried in the Dayton newspapers.

## CONSTELLATION VIEWER

JUNIOR ASTRONOMY CLUB  
CLEVELAND OHIO  
FRANK A MYERS



Sturdiness and ease of operation characterize the viewer, the parts of which are numbered in this detailed drawing to correspond with the descriptions above.



Reproduced from the "American Ephemeris and Nautical Almanac."

## The Next Total Eclipse of the Sun

**A**N IMPORTANT eclipse of the sun will take place on February 25, 1952, one that promises to afford excellent observing opportunities for a number of eclipse expeditions from the United States and other countries. As shown by the accompanying map, the path of totality sweeps from sunrise in the Atlantic Ocean across Equatorial Africa, the Anglo-Egyptian Sudan, Saudi Arabia, Iran, and ends at sunset in Siberia.

Present indications are that most expeditions will be located near Khartoum, on the upper Nile, for there the average cloudiness is 1.2, some of which may be caused by blowing dust and sand; there is no rain, and bright sunlight occurs 93 per cent of the daylight hours, according to a report of Commission 13 of the International Astronomical Union, published in *The Observatory* for April, 1951. This report states that Dr. G. Van Biesbroeck, of Yerkes Observatory, visited Khartoum in February, 1950, when he determined the central line of totality as passing five miles southeast of the city, where several miles of free open desert space should permit many parties to establish their camps. Dr. Van Biesbroeck plans to observe from this region, to repeat the tests of the relativity shift of the light of stars passing the sun; he had previously made them at the eclipse of May 20, 1947, in Brazil.

Expeditions have been provisionally announced as being planned by Cambridge University Observatory, the Royal Greenwich Observatory, the Roy-

al Helwan Observatory, and Dunsink Observatory. The International Radio Scientific Union is co-ordinating all studies of radio effects, especially those related to the ionosphere; the radio parties are to be scattered to produce a maximum amount of information. Two radio telescopes will be taken to Khartoum by an expedition from the Naval Research Laboratory, which is also sponsoring associated optical observations by the High Altitude Observatory of Harvard University and the University of Colorado.

Dr. John W. Evans is leader of this group, which will have Robert Cooper as engineer, who has been in charge of the mechanical design and construction, and Robert Lee as electronics expert.

The bulk of the High Altitude Observatory equipment has already been shipped. It consists of three objective grating spectrographs, equipped with pneumatically operated jumping film magazines similar in principle to those used by D. H. Menzel in Siberia in 1936. Each spectrograph takes two spectra on each exposure, one of which is reduced to about  $1/50$  the intensity of the other; by this means a very long photometric range should be obtained. Exposures will be taken at intervals varying from about  $1/2$  second for the bright lower chromosphere to three seconds for the highest region. The purpose is to obtain more accurate information than is at present available about the spectrum of the chromosphere as a function of height above the sun's photosphere, in the wave length region from

3400 angstroms to 8800 angstroms. The end result is to be a more exact determination of the temperatures and pressures of the chromosphere for comparison with radio observations. These generally indicate that the lower chromosphere is relatively cool, in disagreement with the temperature of about 30,000° centigrade obtained by spectroscopic data.

In addition to the spectra, each exposure will automatically record a timer reading which gives the time and duration of exposure, and a step wedge illuminated by a standard lamp. This wedge is not a primary standard, but only a check to be used in making sure that the characteristic curves of the flash spectrograms and the standard spectrograms are identical. The primary standard spectrograms will be taken through a neutral wedge over the slit immediately before and after the eclipse. The standard source is a calibrated ribbon filament lamp with a controlled power supply.

The three spectrographs will be carried in a single frame which mounts on a 10-foot equatorial spar as a unit which can be set at the appropriate position angle to make the direction of dispersion coincide with the line of contacts of the eclipse. During totality, the High Altitude observers also plan to take two direct photographs of the corona of 10 and 100 seconds exposure, respectively. The duration of totality at Khartoum is about 189 seconds.

Two other expeditions from Colorado are being sponsored by the Air Force, one from the physics department of the University of Colorado to study the zodiacal light, the other from the physics department of the University of Denver to make infrared observations of the eclipse.

The University of Ottawa is planning an expedition, and in *Popular Astronomy* for June, 1951, James Hargreaves describes the problems of "Surveying for an Eclipse Expedition." He discusses the complex nature of the selection of an observing site. The interpretation of meteorological records gives, perhaps, the greatest difficulty, and two kinds of atmospheric scattering are to be taken into account. The first causes the general blue of the sky, as it varies inversely with the square of the wave length; the second is white-light scattering, and is caused by reflecting particles such as water droplets, smoke, or dust. For observations of the outer corona, the observer should be above the white-light haze, which in the Khartoum region generally has its top well defined and between 7,000 and 12,000 feet. Mr. Hargreaves concludes that the best chances for observations of the faint outer corona should be in the Red Sea Hills of the Anglo-Egyptian Sudan, which rise over 5,000 feet.

# Amateur Astronomers

## AAVSO MEETS AT HARVARD OBSERVATORY

**A**LTHOUGH an excessive number of cloudy nights over the world reduced the total observations by members of the American Association of Variable Star Observers during the past recording year to 48,291, the smallest annual number since 1946, the grand total of AAVSO observations has reached 1,393,030. Among the 136 contributing observers this year, R. P. de Kock, of South Africa, led with 5,963 observations. Next came Cyrus F. Fernald, Wilton, Me.; Leslie C. Peltier, Delphos, Ohio; Edward Oravec, Tuckahoe, N. Y.; and Ferdinand Hartmann, St. Albans, N. Y. These top five contributed more than 30 per cent of the total observations.

In her report to the 40th anniversary meeting of the society, held at Harvard Observatory on October 12th and 13th, Recorder Margaret Mayall stated that the favorite variable, SS Cygni, had been carefully watched and no maxima of that star eluded the observers. While the R Coronae Borealis stars have remained inactive for several years, the flare star AE Aquarii has interested more observers. Next year, the AAVSO plans to sponsor an AE Aquarii month, asking observers all over the world to watch the star for at least half an hour each favorable night; thereby it is hoped to catch more of the elusive and relatively short flares.

The opening lecture Friday evening was by Dr. Bart J. Bok, associate director of Harvard Observatory, who discussed the "hub of the universe expedition," which took him to South Africa. He exhibited several plates recently taken with the new Baker-Schmidt telescope.

Two merit awards were presented at the banquet Saturday evening, the 10th to Dr. Harlow Shapley, in appreciation of his co-operation with the society during the 30 years he has been director of Harvard Observatory, and the 11th to David W. Rosebrugh, long-time observer and past president of the AAVSO.

At the top of his list of astronomical highlights of the year, a traditional feature of the AAVSO dinner, Dr. Shapley places the computation with large machines of the positions of the five outer planets from 1653 to 2060, by W. J. Eckert, of International Business Machines Corporation, with G. M. Clemence, U. S. Naval Observatory, and Dirk Brouwer, Yale University Observatory. Dr. Shapley listed the American Academy's solar conference in February, 1951; the measurement of the motions of auroral hydrogen by A. B. Meinel, at Yerkes Observatory; the rapid progress in radio astronomy, with the number of radio stars increased to more than 100; the detection and measurement of 21.3-centimeter microwave radio energy from neutral hydrogen in the Milky Way. The first operation of two special Schmidt telescopes, the ADH instrument in South Africa, and the super-Schmidt for the Harvard meteor station in New Mexico; the measurement of polarization of light from only one of the Pleiades, by John S. Hall, U. S. Naval Observatory; the discovery of 216 new variable stars in the Sculptor system of the local family of galaxies, by David Thackeray, Radcliffe Observatory; and the theory attributing the ice ages to temporary changes in radiation from the sun, proposed by E. Opik, Armagh Observatory, are all highlights of the past year.

Also included are the measurement of radial velocities of 38,000 miles per second for external galaxies, by Milton Humason with the 200-inch telescope, and the demonstration by physicists at the University of Minnesota and Rochester University that primary cosmic radiation is composed of nuclei of elements from hydrogen to iron and heavier, with protons the dominating constituent.

Mrs. Martha Stahr Carpenter, of Cornell University, was elected president of the association for the coming year, succeeding Neal J. Heines, who remains chairman of the Solar Division.

### A POLL OF AMATEUR INTERESTS

Variety and depth of interest are possible in astronomy because of its unlimited scope and many-faceted nature, from unaided visual stargazing to the profundity of mathematical and astrophysical studies.

A questionnaire was recently submitted to our group of 30 amateurs in the Tri-State Astronomical Association, to ascertain the relative interest in eight classifications. Results are used as a guide in preparing talks and discussions.

Two classifications were field activities, including visual observing, star and constellation identification, and telescope and instrument making. In these, 19 and 13 per cent of the group, respectively, were interested. But omitting these subjects, considered suitable for lecture matter in a rather limited extent, we obtained the following percentage of relative interests: solar system, 20; stars in general, doubles, variables, novae, 20; galaxies and problems of the universe, 19; scientific explanations, celestial mechanics, astrophysics, 17; astronomy of the future, such as possible use of radar and rockets to explore space, 15; history, great astronomers, astronomical ideas of earlier times, 9.

It would be interesting to learn what a questionnaire of this type would yield from a large group of amateurs.

H. BARTENBACH  
R. D. 1, Weirton, W. Va.



Members and guests at the 40th anniversary meeting of the AAVSO, October 13, 1951, Cambridge, Mass. Photo by James Ufford.

## SACRAMENTO STAR PARTY

These are some of the instruments used at the first anniversary meeting this summer of the telescope makers forum of the Sacramento Valley Astronomical Society, California, at the home of William A. Ervin. Over 100 persons attended, bringing 15 member-built telescopes, including a 16-inch reflector.



## THIS MONTH'S MEETINGS

**Buffalo, N. Y.:** At the meeting of the Amateur Telescope Makers and Observers on December 5th, Museum of Science at 8 o'clock, Ernst Both will speak about "Planetary Observations, 1951-52."

**Cambridge, Mass.:** "The Origin of Meteorites," by William H. Pinson, Harvard Geophysical Laboratory, will be the feature talk at the Bond Astronomical Club meeting, Harvard College Observatory, December 6th, at 8:15 p.m.

**Chicago, Ill.:** At the December 9th meeting of the Burnham Astronomical Society, 4 p.m. at the Adler Planetarium, Wagner Schlesinger, of the planetarium, will speak on "The Debris of the Universe."

**Cleveland, Ohio:** The Cleveland Astronomical Society will hold its Christmas party on December 14th at the Warner and Swasey Observatory, 8 p.m. "A Motion Picture Study in Natural Science" will be shown by Mrs. Warner Seely.

**Columbus, Ohio:** "The Theory of Relativity" will be discussed by Dr. J. Allen Hynek, McMillin Observatory, at the December 14th meeting of the Columbus Astronomical Society, 8 o'clock in the observatory.

**Dallas, Tex.:** Oscar E. Monnig, of Ft. Worth, will speak at the December 17th meeting of the Texas Astronomical Society, 8 p.m. at the Baker Hotel.

**Detroit, Mich.:** On December 9th, Dr. Stanley P. Wyatt, Jr., University of Michigan Observatory, will address the Detroit Astronomical Society on "Astronomy of Radio and Radar." The meeting is at State Hall, Wayne University, 3:00 p.m.

**Denver, Colo.:** On December 10th at 8 p.m., E. J. Rusho will speak on "Variable Star Observing" at the Denver Astronomical Society meeting at Chamberlin Observatory. A meeting to discuss astronomical instruments is planned for the latter part of December.

**Geneva, Ill.:** On December 11th, the Fox Valley Astronomical Society will hold its Christmas party in the Wheeler memorial hall, Geneva Public Library. Wagner Schlesinger, of the Adler Planetarium, will speak on "The Christmas Star."

**Indianapolis, Ind.:** Dr. John B. Irwin, Indiana University, will speak on "Double Stars and Clusters" at the Indiana Astro-

nomical Society meeting, December 2nd, 2:15 p.m., in Cropsey Hall, Central Library.

**Madison, Wis.:** On December 12th at Washburn Observatory, 8 p.m., the Madison Astronomical Society will hear a discussion of "The Earth-Moon System," by Thomas Stavrum.

**Minneapolis, Minn.:** "Modern Astronomy" will be discussed by Helen Hughes, and "Constellations" by Arthur T. Adams, at the December 5th and December 19th meetings, respectively, of the Minneapolis Astronomy Club, 7:30 p.m., at the Library Science Museum.

**New York, N. Y.:** Dr. Dorrit Hoffleit, Harvard College Observatory, will speak on "First in 20th-Century Astronomy," at the December 5th meeting of the Amateur Astronomers Association, in the American Museum of Natural History at 8 o'clock.

The Junior Astronomy Club will meet at the American Museum on December 21st, 8 p.m., when Dr. Lloyd Motz, of Columbia University, will speak on "Stellar Energy."

**Rutherford, N. J.:** The Astronomical Society of Rutherford will hear Paul J. Hagar discuss "Color in the Sky," at the December 6th meeting, 8 o'clock in the YMCA.

**Sacramento, Calif.:** Dr. Dinsmore Alter, of the Griffith Observatory, will speak at the December 4th meeting of the Sacramento Valley Astronomical Society, 8:00 p.m. in the Little Theater, Sacramento Junior College. His subject will be "The Planet Pluto."

**Washington, D. C.:** The National Capital Astronomers will meet on December 1st at 8:15 p.m. in the Department of Commerce auditorium, when Dr. William Markowitz, U. S. Naval Observatory, will speak on "Some Optical Considerations in Double Star Measurement."

## LEAGUE CONVENTION PROCEEDINGS

The Astronomical League has for sale copies of the proceedings of the Chapel Hill convention. The cost is \$1.00 and the supply is limited. Address your order to Grace C. Scholz, executive secretary, 110 Schuyler Rd., Silver Spring, Md.

## A FIRST TELESCOPE

Recently, I have completed a 6-inch Newtonian reflector, my first telescope. After reading some back issues of *Sky and Telescope*, I contacted a local astronomer and learned of the Amateur Telescope Makers of Spokane, who have given my brother and me (aged 13 and 15, respectively) much assistance.

In March I purchased a mirror kit and began to grind; I finished in July. Then



the telescope proceeded rapidly. Its tube is of 5/8-inch plywood, 50 inches long. The focal length is 55 inches. The mounting is made from 2-inch pipe fittings, with a concrete base, and is quite stable.

At present I have one eyepiece, a Kellner with a field of view of about 3/4 degree and with excellent definition. It produces about 58 power with this telescope.

DAVID HARRIS  
W. 2624 Walton St.  
Spokane 13, Wash.

# TERMINOLOGY TALKS. J. HUGH PRUETT

## Deferents, Epicycles, Fictitious Planets

To Apollonius of Perga (3rd century B.C.) is credited the initiation of the system of planetary deferents and epicycles. Later, the noted Hipparchus added to it. Finally this was given a firm hold on the minds of scientists by the famous Ptolemy, who perfected his hypothesis around A.D. 140. Then for 14 centuries the Ptolemaic system held practically undisputed sway over the scientific minds of the world.

The diagram illustrates the general idea of planetary motions of this system. Ptolemy believed the earth to be the center of the visible universe, fixed in space and without motion. He was modern enough to consider it spherical, but he did not admit its rotation to account for the seeming daily movement of the heavenly bodies around it. In his writings he stated that some believed in a rotating earth. He said such, if true, would allow for a much simpler explanation of the stellar movements. In spite of this, he denounced the theory as ridiculous. He did not seem to have the slight doubts held by King Alfonso X of Spain in the 13th century; when the king's astronomers handed him the Alphonsine tables of planetary motions, which he had ordered computed, he remarked, "If I had been pres-

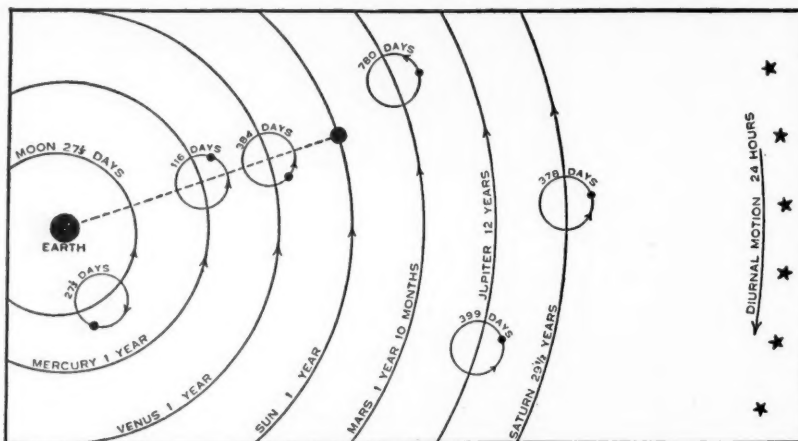
ent at the creation, I could have given some good advice."

On the diagram we find two types of circles, large deferents and small epicycles. As we look down on the north pole of the earth, the motions of the planets on both the large and small circles are from west to east, or counterclockwise. The crystalline spheres were assumed to revolve east to west, or

clockwise, thus giving the daily apparent motions of the heavens.

Since the planets seemingly moved both eastward and westward each year, they required another circle each to explain their motions. The planets did not move exactly along their deferents, but eastward on other circles known as epicycles. The centers of these epicycles, known as the fictitious planets, in turn moved eastward along the deferents.

It was thought that the centers of the epicycles of Mercury and Venus always



The scheme of the Ptolemaic system. In the time of their synodic periods, the planets moved counterclockwise in their respective epicycles. The line between an outer planet and its epicycle center was always parallel to the line between the earth and the sun. The moon's epicycle motion was thought to be clockwise.

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remained on an imaginary line that connected the earth with the sun. These centers then revolved along their crystalline spheres once in the earth's sidereal year. The motions of these planets along the epicycles took them around the centers in a time equal to their synodic periods.

For the bodies beyond the sun, the lines joining the planets to the centers of their epicycles always remained parallel with the line joining the earth and the sun. These planets would thus encircle their epicycle centers in a time about equal to their synodic periods, while the epicycle centers encircled the earth in their sidereal periods.

### Eccentrics

An epicycle was added to the moon, and later a small one to the sun to account for their irregularities in motion. Some astronomers added "epicycles upon epicycles" (not shown in the diagram) to take care of planetary irregularities. Others used the principle of eccentrics. They considered all the deferents and epicycles to be circles, but thought they were "off center" a bit in regard to the earth and the points on the deferents on which the epicycles moved.

What a relief from multiplying complications came when finally the work of Copernicus and Kepler gave us our present system of elliptical orbits with planets encircling a central sun!

# BOOKS AND THE SKY

## THE RESTLESS UNIVERSE

**Max Born.** Dover Publications, Inc., New York, second revised edition, 1951. 315 pages. \$3.95.

**T**HE MOST striking feature of Max Born's book to a casual observer is seven sequences of drawings reproduced in the generous margins. By properly flipping the pages, Hertzian waves, gas molecules, and electrons jump into action, vividly portraying the "restless universe."

The author is recognized as a teacher and leader, well qualified to provide a descriptive account of the rapid progress in modern physics since the turn of the century. His uncommon gifts of analogy and illustration make alive the concepts of quantum mechanics. The book is "popular" in that all but the simplest mathematics have been avoided, and it begins with fundamentals familiar even to a layman. Nevertheless, intelligent reading and concentration are required as Born proceeds from waves and particles to atomic structure.

**The Restless Universe** is more than a popular account of the infinitely small atom in an infinite universe. It expresses the personal philosophy of science not only of Born, but of many of his colleagues. Here is the unlimited optimism that physics is seeking truth and will ultimately find a simple basic expression of the universe in mathematical formulae. Here is the scientific method, graphically illustrated by historical example.

Such is the philosophy of the first 278 pages. With a few exceptions, however, these are an identical reprint of the first edition of 1936. Unfortunately for the book, physics has developed at a remarkable pace in the past decade and a half. Although this period has mostly extended the science of the '30's without refuting it, a book without the atomic bomb, cosmic rays, radar, and resonance, could not presume to give a true picture of modern physics.

Recognizing the problem, the author has added a 37-page postscript to his earlier work. But a devastating world war, utilizing the amoral facts of physics to prepare a weapon of destruction, together with the cloak of secrecy covering much of contemporary physics, has shattered the enthusiastic optimism of pure science and the search for truth. The author has in a cursory manner covered the recent developments. The single sentence devoted to the cyclotron can hardly bring the reader up to date on that subject.

One feature of Born's philosophy has not been negated by the final pages. Rather, he has strengthened his ideas that the science of probability and predicted deviations force a re-evaluation of the theory of determinism. He hopes that not only can the contradiction of free will be resolved, but that there will be a similar solution of conflicting political ideologies in the present world.

The volume is remarkably free from typographical errors, especially the older

part. Pi-mesons are the heavier, and not the mu-mesons as stated on page 295. It is the mu-mesons which decay spontaneously into electrons and, presumably, neutrinos.

OWEN GINGERICH

## PATTERNS IN THE SKY

**W. Maxwell Reed.** William Morrow and Company, New York, 1951. 125 pages. \$2.50.

**S**IMPLICITY and directness characterize this book for the young enthusiast. It may be recommended without hesitation to young people of all ages and to the adult who wants to know something of the romance of the constellations but cannot understand more than the most elementary concepts of the mechanisms of the universe.

Mr. Reed is the author of *The Stars for Sam*, long a standard book for children, as well as *The Earth for Sam* and *The Sea for Sam*. His approach to knowledge is easy but at the same time factual; he has good sense in the selection of subject matter at that level of education where such discrimination is very important.

The scheme of this book is to talk lightly about 25 principal constellations, describing the more popular mythological stories with what seems considerable detail for so small a volume. The star charts

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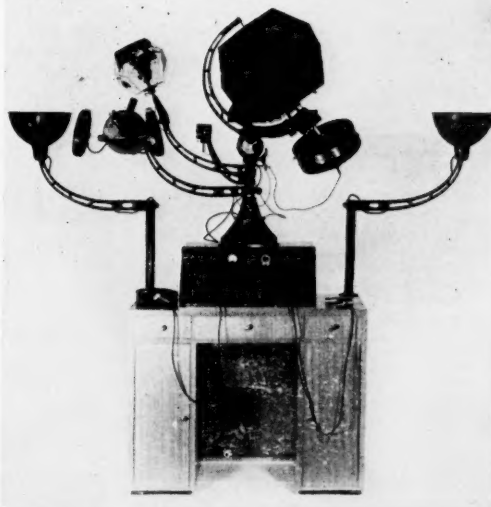
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usually show on one page the mythological pattern of a constellation and on the facing page simple round spots on a black background to represent "exactly how this group of stars looks in the sky." Many charts show several groups at one time, to advantage. Someone familiar with the stars is probably expected to aid the reader in finding most of the groups for the first time.

Mr. Reed is somewhat old-fashioned in his use of terms. "Island universes" are better now called galaxies, including our own, and in no event ought galaxies to be called "clusters." It is very misleading, even for children, to say (page 40), "Nearly all the stars that can be seen

through a telescope are in our own cluster." Even a small child can appreciate such actual clusters as the Seven Sisters and the Beehive.

Although Mr. Reed states that he lives where scorpions are plentiful and would like to put all of them among the stars, his circumpolar chart on page 26 shows Vega well above the northern horizon, as if the observer were at a latitude of about  $55^\circ$  north, some  $15^\circ$  above the usual average of  $40^\circ$  north taken for United States observers. No explanation of this feature is given, and it is hoped care will be taken concerning the idea of circumpolar stars in the book's second edition. C. A. F.

## NEW BOOKS RECEIVED

EDDINGTON'S PRINCIPLE IN THE PHILOSOPHY OF SCIENCE, Sir Edmund Whittaker, 1951, Cambridge University Press. 35 pages. 50 cents.

"The last fourteen years of Eddington's life were spent chiefly in justifying and applying a new Principle which he introduced into the philosophy of science, and which is the central theme of his last book, *Fundamental Theory*." This Eddington memorial lecture evaluates the principle and discusses its progress during the past few years. Whittaker discusses the implications of Eddington's cosmical number, the number of particles in the entire universe, on several recent theories of continual creation, and concludes that empirical evidence favors the views of Eddington.

ASTROPHYSICS, J. A. Hynek, editor, 1951, McGraw-Hill. 703 pages. \$12.00.

Fifteen authors have contributed chapters to this discussion, which reviews the progress in astrophysics of the past five decades, and commemorates the 50th anniversary of the Yerkes Observatory. The book is part text, part handbook, and part treatise, and its sections are devoted to spectroscopic astro-

physics, and to physics of the solar system, of binary and variable stars, and of cosmic matter.

THE AURORAE, L. Harang, 1951, Wiley. 166 pages. \$4.50.

This is Vol. I of the International Astrophysics Series, of which the general editors are Drs. M. A. Ellison and A. C. B. Lovell. The aim of the series is to provide authoritative volumes on astrophysics and radio astronomy, primarily for specialists and students. Dr. Harang is chief scientist of the Norwegian Defense Establishment.

BRITISH SCIENTISTS, E. J. Holmyard, 1951, Philosophical Library. 88 pages. \$2.75.

A series of short biographies gives an account of British contributions to science from Roger Bacon to the present day. The book is illustrated with 24 portraits.

THE HEAVENS ARE TELLING, Urana Clarke, 1951, Acorn House. 128 pages. \$2.95.

Introductory astronomy and constellation study for young people and adult beginners are presented in this book, which is illustrated with drawings by Michael Chadwick and a selection of astronomical photographs.

## ROBERT GRANT AITKEN

(Continued from page 26)

fornia, Dr. Aitken became associate director. Although he relied on Campbell's advice on some matters, the entire administrative responsibility of Lick Observatory fell on his shoulders for the next 12 years, even though he did not accede to the full directorship until 1930.

Dr. Aitken performed the duties of director with painstaking care to the finest detail and with the greatest consideration for members of his staff. Yet, despite the heavy demand on his time for these administrative duties, he carried his full share of observing until his retirement in 1935, at the age of 70. In that year he and Mrs. Aitken, ever his devoted companion and counselor, moved to Berkeley to the home they had just purchased and to which they had been looking forward so long. "Dream True," Mrs. Aitken called it. They had only a short time together in retirement, Mrs. Aitken passing on suddenly shortly afterward.

However, Dr. Aitken for a full 16 years continued a life of devotion and service to astronomy. He spent considerable time at the Astronomical Department in Berkeley, making use of the li-

brary and often discussing scientific problems with staff and students. He became especially active in the affairs of the Astronomical Society of the Pacific, particularly with reference to the editing of its various publications.

Dr. Aitken's observations and general studies of double stars, which include a book on that subject, represent a solid contribution to astronomical knowledge that few people have equaled. Recognition for his work includes several honorary degrees, the Darwin lecturer and gold medal from the Royal Astronomical Society, the Lalande gold medal of France, and the Bruce gold medal of the Astronomical Society of the Pacific.

To the end of his life Dr. Aitken maintained his keen interest in people. He always had a cheerful word for everyone. He was particularly fond of children, and many, now grown, recall the fascination of his massive gold watch, whose hunting case opened like magic whenever he blew on it. Even during his last years, friends the world over watched for and not infrequently received notes in Dr. Aitken's characteristic handwriting.

DONALD H. MENZEL  
Harvard College Observatory

# GLEANINGS FOR ATM's

EDITED BY EARLE B. BROWN

## THE GREMLINS AND MY PHOTOMETER

FOR the last three years there has been open warfare between the gremlins and myself over my photoelectric photometer, and I am happy to state that I finally have gotten the best of them (I hope).

For photoelectric photometry one needs a telescope, of course, a light receiver or phototube, an amplifier, and a meter or recorder to register the measurements. Starting with the telescope, the main requirements are stability and maneuverability.



Fig. 1. The gremlin can't shake the sturdy mounting of Mr. Ruiz' telescope.

The telescope has to be very rigid, for so many things are attached near one end. Furthermore, the setting on a star must not be disturbed when the shutter is operated to get the dark-current readings. David Rosebrugh tells us that for visual work a mounting that will not move when one removes his fingers from the focusing knobs is all that is required (Observer's Page, April, 1950). That is not enough for photoelectric photometry, where the rigidity of an observatory instrument is essential.

At first a gremlin had fun at my expense by shaking the three-inch pipe which was my original stand. I foiled him, however, by sinking a six-inch pipe in concrete below the frost line (Fig. 1).

A good driving clock is needed, that will keep the image of the star within 0.2 millimeter of the center of the field for at least 10 minutes. I found another gremlin was playing with a file on my driving gear, causing it to have backlash. I took care of him by mounting the driving worm on preloaded thrust ball bearings. Note that the telescope has slow-motion controls, which are essential in this work. The telescope is moved frequently from the variable star to one or more comparison stars, particularly in regions where the condition of the sky changes continuously during the night, as in the northeastern United States.

The photoelectric equipment can be any of several designs. Fig. 2 shows that mine consists principally of the holder of the 1P21 photomultiplier tube, a Kron No. 11 amplifier, and an Esterline-Angus recorder (not essential). This apparatus is the happy playground for another enemy gremlin, who takes keen delight in spraying moisture on the terminals of the 1P21 tube. With a potential difference of 810 volts between the famous No. 10 terminal and ground, this is fatal. In spite of precautions, the gremlin has ways of hiding in the most insidious manner. Painting the surfaces with ceresin wax or C4 grease helps keep him off.

Another of these demons (Fig. 3) spills dirt from his underground den on your slide or shutter. The opening of the slide must be only one millimeter in diameter, so that the slightest trace of lint or dirt will cause the needle of the meter to swing erratically as the image of the star passes over the obstruction. The remedy is obvious: Keep your house clean!

Some nights when the transparency is fine and you expect wonderful results, a gremlin will swab the optical surfaces with dew. You won't be aware of his nefarious work until the next day, when you plot the observations and find them scattered all over the graph. You can prevent this gremlin from making a three-point landing on your mirror by slightly heating it with a small electric coil. Incidentally, good seeing is not essential for this type of



Fig. 2. One of the most serious hazards of operating a photomultiplier photometer is that of moisture depositing on the tube terminals.

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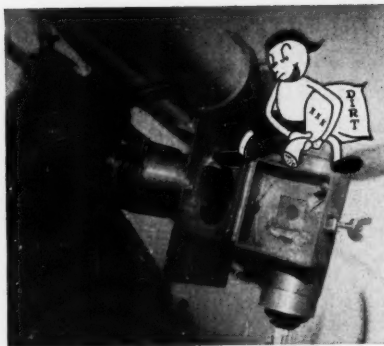


Fig. 3. The free passage of light through the small aperture before the phototube surface can be seriously impaired by dirt and dust.

photometry, but transparency is required. The two do not go together, as explained by Mr. Rosebrugh on the Observer's Page for September, 1951.

After all these precautions had been taken, another gremlin, in Fig. 4, used his flashlight to make the results erratic. A cousin of his sometimes rides on northern lights or on a mare's tail when the moon is shining, and vitiates your results. Once I put a black cloth on my eyepiece to keep him out, only to find that the cloth absorbed moisture and caused leakage currents to jump between the terminals of my phototube. A watch must be kept on the whole sky to see that a weak aurora or moonlight causes no trouble of this kind, and, of course, local sources of extraneous light must be eliminated.

As mentioned already, it is necessary to take a series of readings, in rapid succession, of the variable and comparison star. For recording these, a tape adding machine comes in handy. I had one in operation, and was congratulating myself on the ease with which I could record and average my observations when another villain made his appearance on my observing stand. I had to give up the adding machine when in the quietness of the midnight surroundings I heard my wife whisper from an upstairs room, "You are waking all the neighbors." The way of an amateur astronomer is hard indeed.

It is disheartening to spend a whole night, or at least five or six hours of continuous observing, to find that gremlins have been at work to their utmost delight



Fig. 4. Gremlins that bring extraneous light into the optical system must be eliminated.



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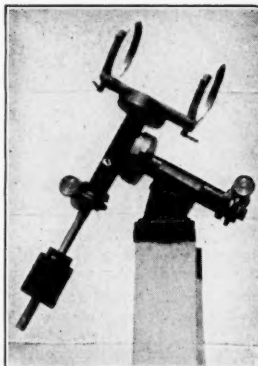
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to present you with a meaningless "curve" like that of Fig. 5. The best way to beat the gremlins is to have as simple an outfit as possible. In the *Griffith Observer*, November, 1950, page 122, Dr. William A. Baum, Mount Wilson and Palomar Observatories, described a simple light receiver built around a camera shutter with an iris diaphragm that can be closed down to one millimeter diameter. In this design, by swinging the phototube aside, the observer can look directly through a field lens at the star being observed, and center it accurately. For convenience and simplicity, this plan can hardly be surpassed. The amplifier has a single electrometer tube and is very stable. Its main disadvantage is that it is nonlinear and has to be calibrated.

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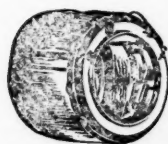


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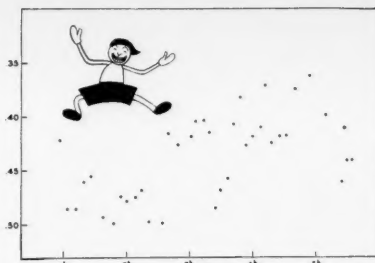


Fig. 5. A wasted night's work.

to show the gremlins I am not afraid of them. For instance, there is the star Flamsteed No. 12 in Lacerta, the Lizard, with a period of 4½ hours. The extreme variation of this star's brightness is only about 0.08 magnitude, too small for most visual observers. After working for five hours, I obtained the typical curve of Fig. 6, to the great chagrin of the gremlins.

This particular star deserves more attention than it has been getting in the past. Dr. E. A. Fath has found that the amplitude varies from night to night, being modulated by second- and third-period variations. Radio engineers call this amplitude modulation. We know that in ordinary broadcasting the intelligence or signal is conveyed by the modulating frequencies. If the same principle is extended to 12 Lacertae, this star has been sending us signals for untold eons. Many amateurs with good photoelectric equipment are needed to obtain more light curves. With considerable care and a little practice, errors can be reduced to about 0.01 magnitude. If a sufficient num-

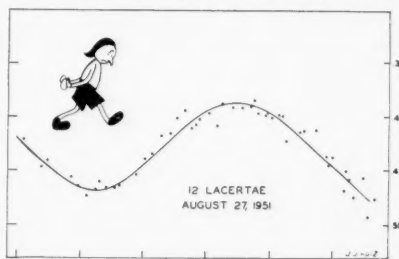


Fig. 6. The vertical scale is magnitude difference, 12 Lacertae minus 10 Lacertae, plotted without a correction for differential extinction. No filter was used.

ber of volunteers can be recruited, and this star is well observed, there may be some interesting results concerning its physical characteristics.

I am loath to say goodbye to my friends the gremlins. Perhaps I have even grown fond of the little fellows. Maybe we shall meet again!

JOHN J. RUIZ  
P. O. Box 115  
Dannemora, N. Y.

ED. NOTE: This account is based on a paper presented at the 40th anniversary meeting of the American Association of Variable Star Observers, October 13, 1951. For further information on photoelectric photometry and the construction of observing equipment, see Gerald E. Kron, "Popular Photometry," *Sky and Telescope*, October, 1947, page 7; John S. Hall and John F. Jewett, "A Simple DC Photometer for Photoelectric Photometry," *Sky and Telescope*, May, 1949, page 169.

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## OBSERVER'S PAGE

Universal time is used unless otherwise noted.

### VISUAL OBSERVING PROGRAMS FOR AMATEURS — XXI

#### Observing the Moon and Planets—(cont.)

**The Moon.** If you are interested in mapping the details in specific craters, it is suggested that you write to the British Astronomical Association for the allocation of an area which you can follow carefully, lunation after lunation. Certain lunar areas, such as the crater Conon, appear to change as the elevation of the sun as seen from the crater varies. Are these changes in appearance caused by the illumination, or are there actual changes? Could they be physical, such as the drying out of water of crystallization, or caused by vegetation?

The simplest tests are to see whether the varied appearance repeats lunation after lunation, and to determine whether the appearance of the crater changes materially from before an eclipse of the moon to afterwards. If it does, then the change is presumably cold-induced, as the angle of illumination of the crater is not very different after totality than before.

If you are going to look for possible changes in craters at the time of a lunar eclipse, become familiar with the area under review for several months before the eclipse. Then observe the area just before the earth's umbra passes over it and again immediately after it emerges from the umbral shadow.

Some work has been done on this general problem by looking at the suspected variable area when it is illuminated by earthshine, but large apertures of from 12 to 18 inches are recommended for such studies.

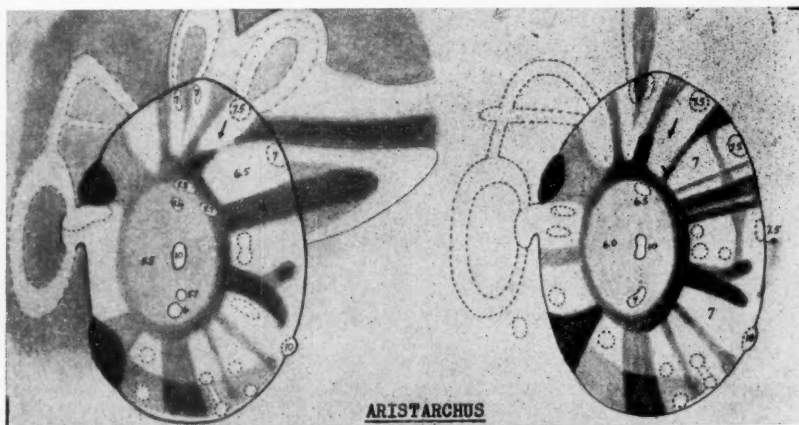
An eclipse of the moon also offers a unique, but by no means the only opportunity to watch for possible meteor flashes and impact flares on the surface of the moon. This is an activity which can be better done by a group than by a solitary

observer. It is very desirable to keep the moon under observation continuously, using two or more telescopes of more-or-less comparable power set up near each other. To rest the eyes, observers should be changed every five or 10 minutes, if there are enough observers.

If any flashes of light are seen which might be meteor flashes or meteorite impact flares, note the exact time to the second, and mark the location and direction of motion of the flash on a sketch of the moon. If two observers side by side see such a flash, it can conceivably be a telescopic meteor in the earth's own atmosphere. If by a fortunate chance someone many miles away sees the same flash at the same time at the same location on the moon, it must be a selenographic phenomenon.

The moon and the planets occasionally become associated in spectacular fashion during occultations. In fact, the casual observer like myself looks at occultations principally as exciting celestial spectacles, but more enterprising observers time occultations of stars exactly, thereby deriving results of value to science. (This is our next general subject.)

In 28 years, I think I have seen but three occultations of planets, as these are comparatively rare. The occultation of Venus on February 7, 1951, was clouded out, but I saw that of January, 1923, and also that of Jupiter in January, 1944. In January, 1948, Mars and the moon had a close approach, and Walter H. Haas told me that the Mars occultation of February that year was likely to be tangential at Waterbury, Conn. He urged me to follow this to see whether there was any dark line across the disk of the planet where it was intersected by the limb of the moon. If so, it might indicate a thin atmosphere close to the moon.



Drawings of the lunar crater Aristarchus, made by E. J. Reese with a 6-inch reflector, 240 power: (left) January 16, 1949, 4:00 UT; (right) October 8, 1949, 5:05 UT. Mr. Reese points out that a number of the minor differences may represent observational errors, but he feels rather confident that the orientation of the foot of a wall band (marked by arrows) is normal at X and abnormal at Y. A lunar eclipse occurred on October 7, 1949. The numbers are intensities.

Reproduced courtesy Association of Lunar and Planetary Observers.

I observed this tangential occultation with my 6-inch reflector and a 75x orthoscopic eyepiece, and have seldom seen a more intriguing sight. For some minutes the southern limb of the moon almost bisected Mars. Sure enough, there was a dark line perhaps a second of arc wide crossing the planet at the edge of the moon, but it soon became apparent that the earth-moon-sun angle was such that the moon was just not quite full at the south pole — the dark line I was seeing was merely a foreshortened view of the sunless southern limb of the moon. So ended in unforeseen failure my one chance to contribute my mite to this lunar atmosphere problem. However, the scene itself was gorgeous, with the half dome of Mars of a hay yellow color looming up over the snow-white lunar mountains.

DAVID W. ROSEBRUGH  
79 Waterville St.  
Waterbury 10, Conn.

### METEORS IN DECEMBER

Full moon in Taurus on December 12th, the date of the Geminid shower maximum, makes this an unfavorable year for these meteors. But the shower is rich and well worth observing in spite of the moon, for the predicted rate is 60 per hour under good conditions. The radiant is near the star Castor, and meteors may be observed several days before and after the maximum. Geminids are slow, with many bright and trained meteors best observed before midnight.

E. O.

### JUPITER'S SATELLITES

Jupiter's four bright moons have the positions shown below for the Universal time given. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, eclipses and occultations by black disks at the right. The chart is from the *American Ephemeris and Nautical Almanac*.

Configurations at 2° 0' for an Inverting Telescope									
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### MINIMA OF ALGOL

December 2, 10:57; 5, 7:46; 8, 4:35; 11, 1:24; 13, 22:13; 16, 19:02; 19, 15:51; 22, 12:40; 25, 9:29; 28, 6:19; 31, 3:08.

These predictions are geocentric (corrected for the equation of light), based on observations made in 1947. See *Sky and Telescope*, Vol. VII, page 260, August, 1948, for further explanation.

### MOON PHASES AND DISTANCE

First quarter ..... December 5, 16:20  
Full moon ..... December 13, 9:30  
Last quarter ..... December 21, 14:37  
New moon ..... December 28, 11:43  
First quarter ..... January 4, 4:42

	December	Distance	Diameter
Apogee	16, 3 <sup>h</sup>	252,400 mi.	29' 25"
Perigee	28, 23 <sup>h</sup>	221,900 mi.	33' 28"

	January	Distance	Diameter
Apogee	12, 6 <sup>h</sup>	252,500 mi.	29' 24"

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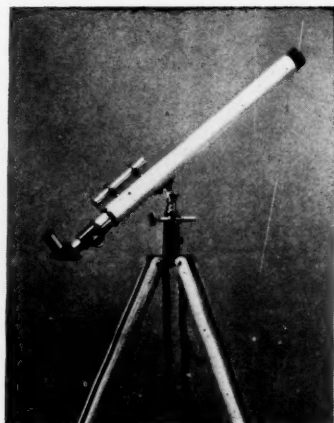
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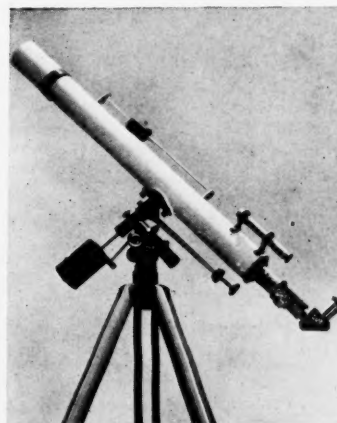
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Several of the Pleiades, including Merope, are enshrouded in nebosity.

## DEEP-SKY WONDERS

**A**MATEURS who find that modern astrophysical journals deal with matters far beyond amateur scope should delve into the British and American journals of the 19th century. For example, a most interesting argument raged in the *Monthly Notices* of the Royal Astronomical Society in the early '80's about the visibility of the nebula around Merope in the Pleiades. Few amateurs today try to observe this object, yet it was discovered by the eye and telescope and was quite a popular test object 70 years ago.

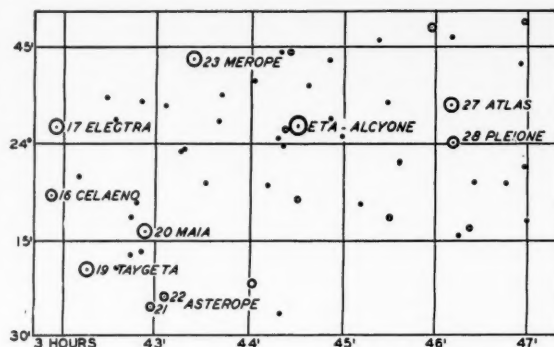
Lewis Swift (the Leslie Peltier of his day) writes (XLII, 107) that he saw the Merope nebula independently in 1874, when he mistook it for a comet. Swift claims he saw the nebosity with only 2-inch aperture and a power of 25. He ventures some interesting comments on

the visibility of nebulosities in various-sized telescopes. At the same time Burnham, unable to see the nebula with the 18-inch at Chicago, asserted it did not exist. Later in the same volume of *Monthly Notices*, T. W. Backhouse (page 358) reports how he saw the nebula with a 4½-inch refractor. The original discovery seems to have been made by Tempel in 1859.

Today, with our modern coated lenses, it should be easier for the amateur than for Swift and his contemporaries. This column would like to hear of the success of any amateur who locates the nebula. If you can, compare coated and non-coated eyepieces. A warning, however: Swift says the Merope nebula is much fainter than M33. If you cannot easily locate M33, you will probably fail with the Pleiades.

WALTER SCOTT HOUSTON

A chart of the Pleiades, oriented with south at the top, for comparison with the photograph at the left. The brighter stars are indicated by circles, and their Flamsteed numbers are given. The fainter stars are plotted without an indication of their relative magnitudes.



## OCCULTATION PREDICTIONS

December 15-16 Kappa Geminorum 3.7, 7:41.5 +24-31.0, 17, 1m: A 1:01.1 +0.6 +2.8 48; B 1:11.7 +1.0 +4.1 32; C 0:54.8 +0.6 +2.3 54; D 1:11.0 ... 29. Em: A 1:44.4 -1.0 -0.6 323; B 1:39.6 -1.4 -1.9 340; C 1:41.5 -0.8 -0.2 315; D 1:35.0 ... 343.

For standard stations in the United States and Canada, for stars of magnitude 5.0 or brighter,

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Harvard Observatory, Cambridge 38, Mass.

data from the American Ephemeris and the British Nautical Almanac are given here, as follows: evening-morning date, star name, magnitude, right ascension in hours and minutes, declination in degrees and minutes, moon's age in days, immersion or emersion; standard station designation, UT, a and b quantities in minutes, position angle on the moon's limb; the same data for each standard station westward.

The a and b quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude, respectively, enabling computations of fairly accurate times for one's local station (long. Lo, lat. L) within 200 or 300 miles of a standard station (long. LoS, lat. LS). Multiply a by the difference in longitude (Lo - LoS), and multiply b by the difference in latitude (L - LS), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Universal time to your standard time.

Longitudes and latitudes of standard stations are:

A +72°.5, +42°.5	E +91°.0, +40°.0
B +73°.6, +45°.6	F +98°.0, +31°.0
C +77°.1, +38°.9	G +114°.0, +50°.9
D +79°.4, +43°.7	H +120°.0, +36°.0
I +123°.1, +49°.5	

## VARIABLE STAR MAXIMA

December 16, S Herculis, 7.6, 164715; 20, R Trianguli, 6.3, 023133; 21, R Ophiuchi, 7.6, 170215; 30, R Bootis, 7.3, 143227.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the predicted magnitude, and the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern).

## PREDICTIONS OF BRIGHT ASTEROID POSITIONS

NOTE: The list entitled "Bright Minor Planets for 1952," which provides the ephemerides from which these predictions will be taken this coming year, is available to any interested person on request to the Cincinnati Observatory, Observatory Place, Cincinnati 8, Ohio. Enclose a self-addressed stamped envelope.

Laetitia, 39, 9.5. Dec. 10, 7:06.9 +9-01; 20, 6:59.3 +9-09; 30, 6:50.4 +9-31. Jan. 9, 6:41.2 +10-04; 19, 6:32.8 +10-48; 29, 6:26.1 +11-37.

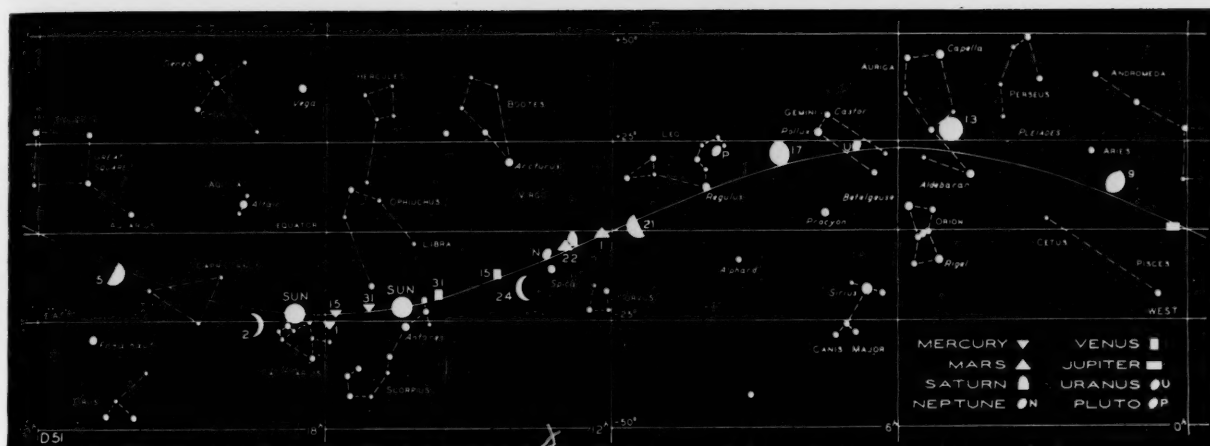
Davida, 511, 8.8. Dec. 20, 8:03.6 +20-08; 30, 7:57.4 +21-24. Jan. 9, 7:49.4 +22-46; 19, 7:40.7 +24-08; 29, 7:32.3 +25-23. Feb. 8, 7:25.3 +26-26.

Iris, 7, 7.8. Dec. 30, 8:24.7 +13-49. Jan. 9, 8:15.0 +13-42; 19, 8:04.0 +13-47; 29, 7:53.1 +13-59. Feb. 8, 7:44.1 +14-15; 18, 7:38.1 +14-32.

After the asteroid's name are its number and the magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1951.0) for 0<sup>h</sup> Universal time. In each case the motion of the asteroid is retrograde. Data supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.

## UNIVERSAL TIME (UT)

TIMES used on the Observer's Page are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, and the result is your standard time on the day preceding the Greenwich date shown.



## THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month and for other dates shown.

**Mercury**, during the first week of December, sets one hour after the sun and is of zero magnitude. The planet passes inferior conjunction on December 17th, and becomes an easy object in the morning sky the last five days of December, rising 1½ hours before the sun and again of zero magnitude. Greatest elongation will occur January 6th, 23° 2' west of the sun.

**Venus** remains the brilliant morning object rising 3½ hours ahead of the sun, moving eastward through Virgo and Libra. It is of magnitude -3.8 on the 15th, telescopically gibbous in phase and 18" in apparent diameter in mid-December.

**Earth** arrives at heliocentric longitude 90° on December 22nd at 16:01 Universal time. Winter commences in the Northern Hemisphere and summer in the Southern.

**Mars** spent the year quite inconspicuously, but it will brighten to 1st magnitude in late December. Moving eastward in Virgo, Mars will be about 17' north of the star Eta on December 1st, and about 5° north of Spica on the 31st. Mars will be relatively close to Saturn all month, conjunction of these planets occurring December 19th at 13:00 UT, faster-moving Mars passing 40' south of Saturn, but the latter will be slightly brighter.

**Jupiter** is in Pisces, on the meridian in the early evening and setting shortly after midnight. Eastern quadrature of Jupiter and the sun occurs on December 28th, when the planet will shine at magnitude -2.1.

**Saturn** appears as a 1st-magnitude object in Virgo during the morning hours,

in conjunction with Mars on the 19th. The rings of Saturn are inclined 9° to our line of sight on the 15th, with their northern face visible.

**Uranus**, above the horizon all night, is easy to observe with slight optical aid. Observations several days apart will disclose its motion westward at a point about 3° northwest of Zeta Geminorum. For its path, see page 103 of *Sky and Telescope*, February, 1951. During 1951 there was no opposition of Uranus to the sun, a situation occurring only about once in 84 years.

**Neptune** will be in a position for field-glass observation three hours preceding dawn.

**NOTE:** During the last few days of December, the five bright planets and the three faint ones will be above the horizon sometime after midnight. At dawn, all will be above the horizon except Jupiter.

E. O.

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The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of December, respectively.

## STARS FOR DECEMBER

DECEMBER SKIES display the most extensive myth on the entire celestial tapestry. In the northern regions of the sky, Queen Cassiopeia, proud and vain, with King Cepheus opens the story. On a day near the dawn of history, the queen boasted that she was more beautiful than anyone else, including the famed sea nymphs. This provoked the wrath of

Neptune, mighty ruler of the sea, who took revenge by sending the monster, Cetus, to devour the inhabitants and devastate the sea coast of Cepheus' kingdom.

Cetus' rambling stellar outline is on the meridian this month, lying across the celestial equator. The circle of stars including Menkar pictures his enormous jaws.

On the advice of an oracle, Cepheus ordered his daughter, Andromeda (repre-

sented by the long curving V just south of Cassiopeia's W), to be chained by the sea as a sacrifice. But just in time our hero, Perseus, rode up on Pegasus, the great winged horse. He slew the wicked monster, cut the chains, and rode off with the beautiful Andromeda as his bride.

Both Perseus and Pegasus occupy conspicuous places in the sky this month, to complete the celestial representation of an old legend.

